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This manual was developed for students participating in the oceanology program offered on the Orange County's Marine Science Floating Laboratory. The program is experience-centered and provides for the students utilizing much of the same equipment used by professional oceanologists. The manual is divided into two sections: (1) "The Immediate Environment I-Physical Properties of the Oceans" and (2) "The Immediate Environment II-Biological Properities of the Oceans." Included for each section is background information and a discussion of techniques for studying specific properties of the oceans. Pictorial taxonomic keys, a glossary of terms, and other pertinent information are appended. (RS)

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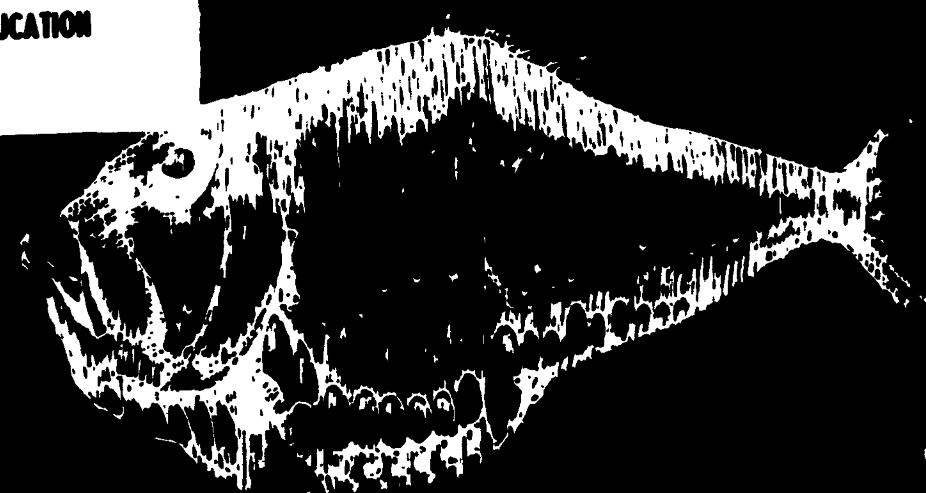
Marine Sciences Student Syllabus



ORANGE COUNTY MARINE SCIENCE FLOATING LABORATORY

ORANGE COUNTY SUPERINTENDENT OF SCHOOLS OFFICE

1968 - 1969

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MARINE SCIENCE STUDENT SYLLABUS

1968 - 1969
2nd Edition

MARINE SCIENCE FLOATING LABORATORY
(USOEG 3-7-703779-4257)

ORANGE COUNTY SUPERINTENDENT OF SCHOOLS OFFICE

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TABLE OF CONTENTS

TABLE OF CONTENTS

INTRODUCTION

Welcome aboard the Fury II, Orange County's Marine Science Floating Laboratory. You'll be taking a cruise today as the result of an increasing need for our county to generate interest in the environment that accounts for 70% of the surface area of the world.

The oceans offer the inquisitive, adventurous, scientific-minded, or fishing enthusiast many hours of pleasure and satisfaction. Today's experience in a "Hands-on Practice of Science" will give you a greater understanding of this marine world and a better appreciation of its opportunities.

The study of the oceans is termed OCEANOLOGY. This study encompasses the fields of biology, chemistry, geology, meterology, and physics. Its major concern is to sample the marine environment and to identify both its physical and biological properties. Various types of instrumentation and equipment are used by professional oceanologists for this purpose. During today's cruise you will be using the same types of instruments and equipment the professional uses.

We hope that this cruise will stimulate your interest in the marine environment and that you will enjoy your day at sea. This syllabus is a guide to a limited study of the marine environment and an attempt to place in perspective the characteristics of this world.

Ronald B. Linsky, Director
Floating Laboratory Project

LIST OF FIGURES

THE IMMEDIATE ENVIRONMENT I

The general characteristic of the immediate environment may be divided into two categories. The physical properties and the biological properties. First let's consider the physical environment and its properties.

PHYSICAL PROPERTIES OF THE OCEAN - The oceans account for roughly 71% of the surface area of the earth but represent less than one per cent of the explored area. How much water is there? The oceans represent a total volume of 325 million cubic miles of water, which if placed into cubic mile containers and then laid end to end would reach to the sun and back about three and one-half times.

The largest of the oceans, the Pacific, comprises three eighths of the total area of the seas. The Pacific is the deepest of the ocean basins with the deepest recorded depths. The Challenger Deep, a part of the Marina Trench measured 35,800 feet when Lt. Cdm. Don Walsh aboard the U.S. Navy Bathyscaph Trieste descended on January 23, 1960.

Sometimes overlooked is the fact the oceans are really 95% water, ordinary H_2O. However, the remaining 5% gives the oceans their unique properties. On page 2 you will find certain physical properties of water and the forty-two most abundant

elements found in the oceans (Figures 1 and 2). The list of elements does not include the oxygen and hydrogen that make up the water molecule.

Of the 5% mentioned previously about 75% is composed of sodium chloride (NaCl), commonly called table salt. It has been estimated that there is about 50 million billion tons of salt in all the oceans of the world.

CERTAIN PHYSICAL PROPERTIES OF WATER

Property	Comparison with other substances	Importance in physical-biological environment
Heat capacity	Highest of all solids and liquids except liquid NH_3 (ammonia)	Prevents extreme ranges in temperature. Heat transfer by water movements is very large. Tends to maintain uniform body temperature
Thermal Expansion	Temperature of maximum density decreases with increasing salinity. For pure water: 4°C	Fresh water and dilute sea water have their maximum density at temperatures above freezing point. This property plays an important part in controlling temperature distribution and vertical circulation in lakes
Surface tension	Highest of all liquids	Important in physiology of the cell. Controls certain surface phenomena and drop formation and behavior
Dissolving power	In general dissolves more substances and in greater quantities than any other liquid	Obvious implications in both physical and biological phenomena
Electrolytic dissociation	Very small	A neutral substance, yet contains both H^+ and OH^- ions
Transparency	Relatively great	Absorption of radiant energy is large in infrared and ultraviolet. In visible portion of energy spectrum there is relatively little selective absorption, hence is "colorless." Characteristic absorption important in physical and biological phenomena
Conduction of heat	Highest of all liquids	Although important on small scale, as in living cells, the molecular processes are far outweighed by eddy conduction

Figure 1

THE 42 MOST ABUNDANT ELEMENTS IN SEA WATER
(% by Weight)

Oxygen	(O)	85.89	Rubidium	(Rb)	$2. \times 10^{-5}$	Molybdenum	(Mo)	5×10^{-8}
Hydrogen	(H)	10.82	Lithium	(Li)	1.2×10^{-5}	Cerium	(Ce)	4×10^{-8}
Chlorine	(Cl)	1.90	Aluminum	(Al)	1.0×10^{-5}	Silver	(Ag)	3×10^{-8}
Sodium	(Na)	1.06	Phosphorus	(P)	5×10^{-6}	Vanadium	(V)	3×10^{-8}
Magnesium	(Mg)	0.13	Iodine	(I)	5×10^{-6}	Lanthanum	(La)	3×10^{-8}
Sulphur	(S)	0.088	Arsenic	(As)	1.5×10^{-6}	Yttrium	(Y)	3×10^{-8}
Calcium	(Ca)	0.040	Barium	(Ba)	1.0×10^{-6}	Copper	(Cu)	2×10^{-8}
Potassium	(K)	0.038	Zinc	(Zn)	5×10^{-7}	Nickel	(N.)	1×10^{-8}
Bromine	(Br)	6.5×10^{-3}	Manganese	(Mn)	5×10^{-7}	Scandium	(Sc)	4×10^{-9}
Carbon	(C)	2.8×10^{-3}	Lead	(Pb)	4×10^{-7}	Mercury	(Hg)	3×10^{-9}
Strontium	(Sr)	1.3×10^{-3}	Iron	(Fe)	2×10^{-7}	Gold	(An)	4×10^{-10}
Boron	(B)	4.8×10^{-4}	Cesium	(Cs)	2×10^{-7}	Radium	(Ra)	7×10^{-15}
Silicon	(Si)	2.0×10^{-4}	Uranium	(U)	1.5×10^{-7}			
Fluorine	(F)	1.4×10^{-4}	Selenium	(Se)	1.0×10^{-7}			
Nitrogen	(N)	$0.3.7 \times 10^{-5}$	Thorium	(Th)	5×10^{-8}			

Figure 2

For the oceanographer the fundamental chemical property of the oceans is <u>salinity</u> or the amount of dissolved salts in a given volume of water. The salinity of the oceans averages about 3.5 per cent or approximately 35 parts salts per 1000 parts of water. This is usually expressed as 35 parts per 1000 or 35‰. This will vary according to the location in the world of the water mass being sampled. In the colder climates where little evaporation occurs the salinity is less than 5‰ and in the hotter areas of the world salinity may reach 40‰ or above.

Another property of the sea is <u>density</u>. This is the weight per unit volume of a substance. The more salts in a given volume of water the more dense it will become and, therefore, it will be able to support more weight. Because of the principle of density the largest animal known on the earth, the dinosaur, was able to be supported in sea water. Many spent most of their lives in lagoons and bays being supported or buoyed up by the water. Today we see the same principle applying to the largest living animal, the whale.

A third physical property of major interest to the marine scientist is <u>pressure</u>. At sea level man is subjected to 14.7 pounds of pressure per square inch of body surface. In the water, however, the pressure increases 14.7 pounds per square inch for every33 feet of depth in addition to the 14.7 pounds per square inch exerted on the surface. Therefore at 33 feet depth a diver would experience a pressure of 29.4

pounds per square inch. At approximately 36,000 feet depth the Bathyscaph Trieste was experiencing a pressure greater than 8 tons per square inch of surfac area.

Other properties of interest to oceanographers are temperature and ‹ ed oxygen content. These are rapid changes in temperature over a small depth range. <u>Haloclines</u> can be determined by sampling water at various depths to determine rapid increases in the salt content from uniform surface salinity to uniform salinity below the dpeth of rapid change. <u>Oxygen-minimum layers</u> are determined by using oxygen analyzers of various types. Again amounts of oxygen are greater above and below this layer. Oxygen-minimum layers usually follow rather closely the thermoclines. The following diagrams illustrate these principles.

GRAPHIC ILLUSTRATION OF TEMPERATURE, SALINITY AND DISSOLVED OXYGEN

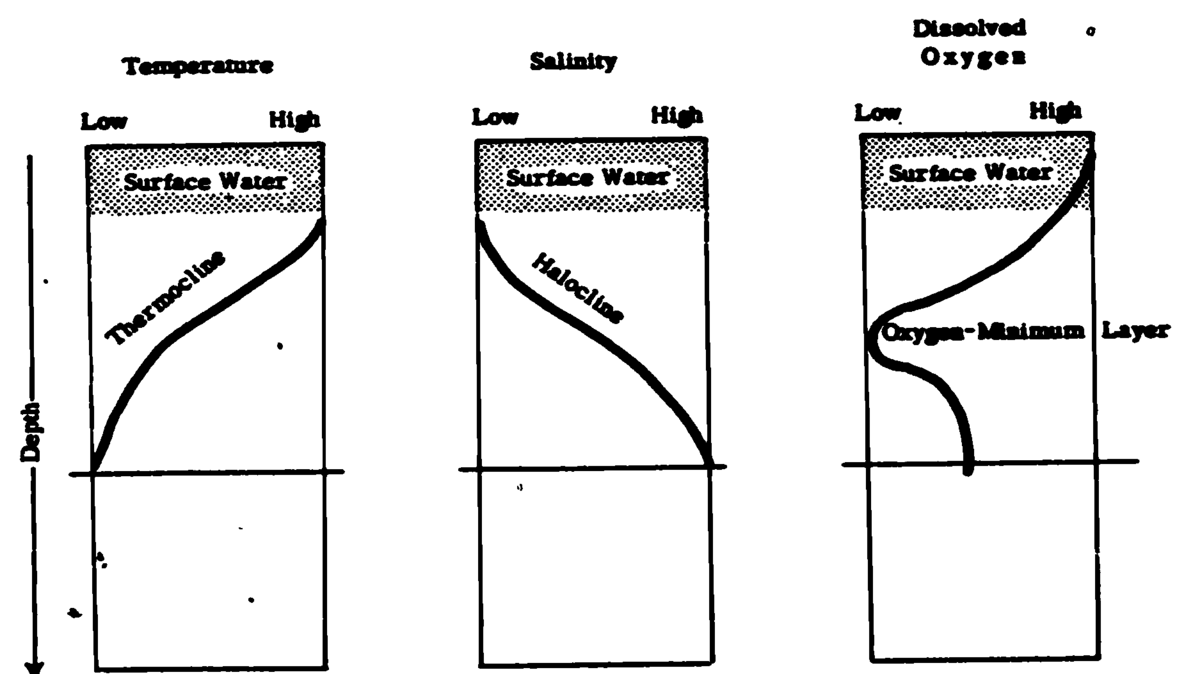


Figure 3

Another of the many aspects of physical oceanography is devoted to answering the question "What does the land mass below the surface of the water look like?" Topography is the study or the art of presenting on charts what a land mass looks like. The study of <u>bathymetry</u> deals with this problem of charting the ocean basins. The chart or map that is produced is called a bathymetric chart.

Historically, man obtained this type of information by means of hemp or wire lines lowered into the water hopefully reaching the bottom in a straight line. You can see that this older method would have shortcomings and provide inaccurate data on the ocean depths.

Today the basic instrument of bathymetry is a sonic device called an echo-sounder or fathometer. This instrument transmits sound waves from a ship by sending energy pulses below the surface level of the water and then by means of a receiver retrieves the reflected sound waves. These reflected waves can then be amplified to produce an electrical impulse which can then be converted into a graphic presentation of the bottom. These measurements are extremely accurate.

Figure 4

Over the years oceanographers have been able to gather information relating to the basin profiles and have developed bathymetric charts of the major oceans of the world. The physical oceanographer recognizes three major divisions of the ocean floors: the Continental Margin, the Ocean Basin Floor and the Mid-Ocean Ridges.

The Continental Margin is characterized by the Continental Shelf, the Continental Slope and the Continental Rise (Figure 8). These are shallow water divisions and are generally characterized by their seaward slope. Characteristically found here are trenches, plateaus, and submarine canyons.

The Ocean Basin Floor division accounts for about one-third of the Atlantic and Indian Ocean basins. The Abyssal plains and hills, Seamounts, Guyots, and Islands Arcs are characteristic of this division. (See YASSO, page 80)

The third classification is the Mid-Ocean Ridges. These are rugged mountain ranges that extend many miles north to south or east to west. An example of this feature would be the East Pacific Rise extending from New Zealand into the Gulf of California a distance of 8000 miles. A rather impressive mountain range, this rise pushes up from the floor to an average of 6500 to 9800 feet and is 1250 to 2500 miles wide.

An understanding of Currents, Tides and Waves is also a part of the physical oceanographer's responsibility. What they are and how they effect the environment is important if he is to have a complete picture of the ocean world.

Sea water is constantly in motion. This motion is produced by a number of forces.

First, the earth is in motion on its own axis and around its orbit of the sun. Because of the principle that a moving object tends to veer from a straight line in relation to the earth's rotation, water masses tend to veer right in the northern hemisphere and left in the southern hemisphere. This is called the Coriolis effect after the French scientist who described it. As the water masses move to right and left respectively they run into the land masses causing them to deflect and develop the basic ocean circulatory patterns. This pattern can be seen by water moving from east to west at the equator then north along Japan across to Alaska and south along the western U.S. Thus, you notice water in the northern hemisphere circulates clockwise and in the southern hemisphere in a counter-clockwise pattern.

Also, acting upon the water is the effect of wind. Wind, you recall, develops from the alternating heating and cooling of the air masses. As warm air rises, the cooler air moves in to take its place, thus setting air molecules into motion. The movement of air masses over large bodies of water are the primary developers of waves. The air movement over water tends to produce friction pushing the water molecules until they build up and absorb the energy from the air, thus energizing other water molecules along the surface producing currents. Wind is the major source of energy of the surface water, however, the differences of temperature and salinity are primary causes of the sub-surface currents.

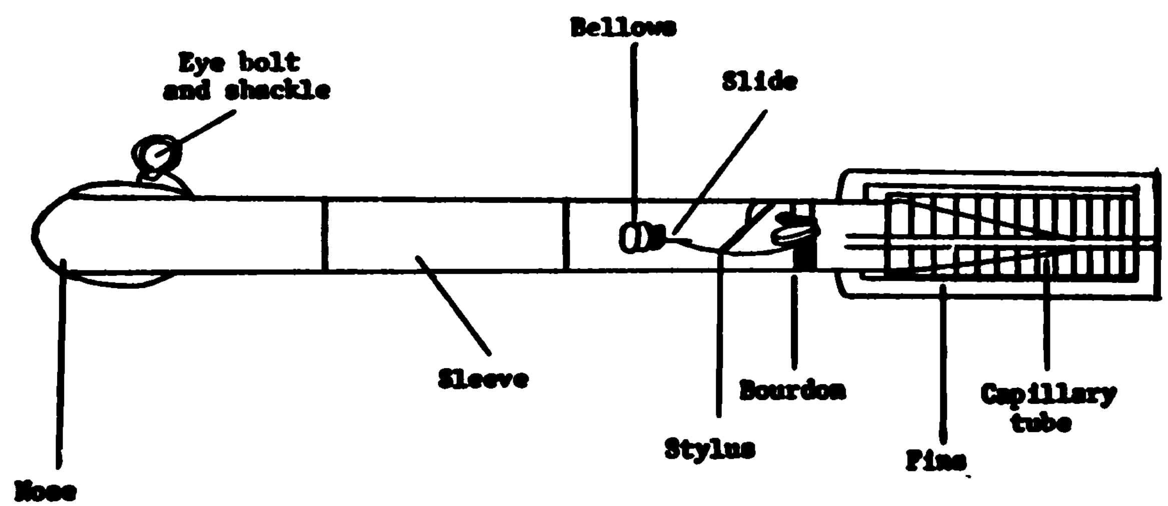
Tides produce their effect on the earth under the direction of the moon and sun with moon affecting more control than the sun. The principle of gravity underlies the role of

the moon and sun on the waters of the earth. The moon attracts the ocean mass, but not sufficient to overcome the earth's gravity. This results in a <u>tidal bulge</u> of the water mass facing the moon. You will note, however, that these bulges occur on both sides of the earth. The sun has little or no effect by itself on the oceans; however, when the sun, moon and earth are lined up, their effect is accumulative and we have our highest tides. When the water bulges in one area, it is reduced in another. This lower level is referred to as the low tide region. Tidal bulges occur every twelve hours. The highest tides, or spring tides, occur every fortnight, or 14 days.

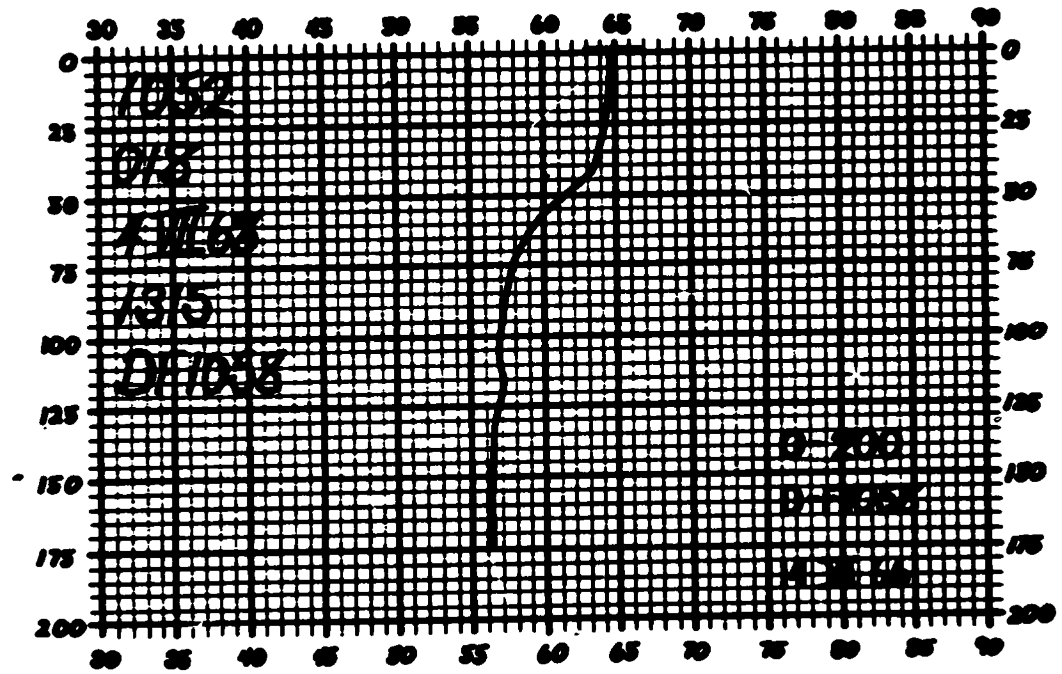
METHODS OF SAMPLING THE PHYSICAL ENVIRONMENT

We've just reviewed the physical properties of the Immediate Environment and now we will discuss some of the instruments that the physical oceanographer uses for sampling the environment.

BATHYTHERMOGRAPH - The bathythermograph (BT) can be considered a work horse for the oceanographer. The instrument contains a bellows that contracts with increase in pressure as the instrument descents into the ocean and a Bourdon element that responds to temperature changes. This torpedo-shaped instrument at the end of a light cable can be lowered into the water from a moving vessel (a very valuable attribute). During its descent and ascent a record of the temperature is plotted against depth on a small glass plate.



Bathythermograph



BT slide as seen through viewer

Figure 5

The principle involved is mechanical involving a temperature responsive element marking a scratch slide which moves in response to depth. The temperature element (under the fins) is exposed to the water while the Bourdon unit is shielded with the casing. (Figure 5).

The main casing of the BT is a stout brass tube which houses the pressure element toward the rear end. The slide holder is fitted in the intervening space. A sliding brass sleeve that fits over the main casing can be drawn back to expose the slide holder for insertion of the slide. A heavy brass streamlined nose piece and sleeve fit over the forward part of the casing and to the nose is fastened the bracket for the towing cable. Fins are attached at the rear and give stability when diving. The pressure element consists of water-tight metal bellows enclosing a carefully wound steel compression spring inside of which there is a piston and cylinder device acting as a guide. One end of the bellows is permanently attached to a brass end piece within the body and the other to the slide holder that takes the small scratch slide on which the stylus marks. This is in contact with the compression spring and is free to follow its movements. Thus, as the pressure increases the slide holder is drawn under the writing stylus, which in the absence of temperature changes would then scratch a straight line.

The thermal element is a liquid thermometer consisting of a capillary and Bourdon tube, the latter being connected to the stylus; changes of temperature would cause the stylus to move in an arc across the scratch slide if pressure remained constant. The

capillary tube is taken outside the main casing and wound on six slotted fins, where it is fully exposed to the surrounding water.

The instrument, with the slide and pen in position, is lowered over the side and towed at the surface for half a minute. The wire is then laid out as fast as possible while the ship is underway, and then approaching the required or maximum depth the rope or hydro cable is slowly brought to a halt. After coming to a rest the instrument is brought up. The slide will have a temperature-depth record scratched on it. There may be one trace for the descent and one for the ascent; often the two are coincidental. The slide is inserted into the viewer and read off against the calibrated grid.

DISSOLVED OXYGEN IN SEA WATER - The amount of dissolved oxygen in sea water is basically dependent upon water temperature and the amount of oxygen in the air above. As the water temperature increases the amount of dissolved oxygen the water can hold decreases. If the air above the water has a higher concentration of oxygen than the water, the oxygen tends to move into the water. If the sea water, on the other hand, has more oxygen than the air, oxygen will tend to move out of the water into the air. Figure 6 illustrates this point.

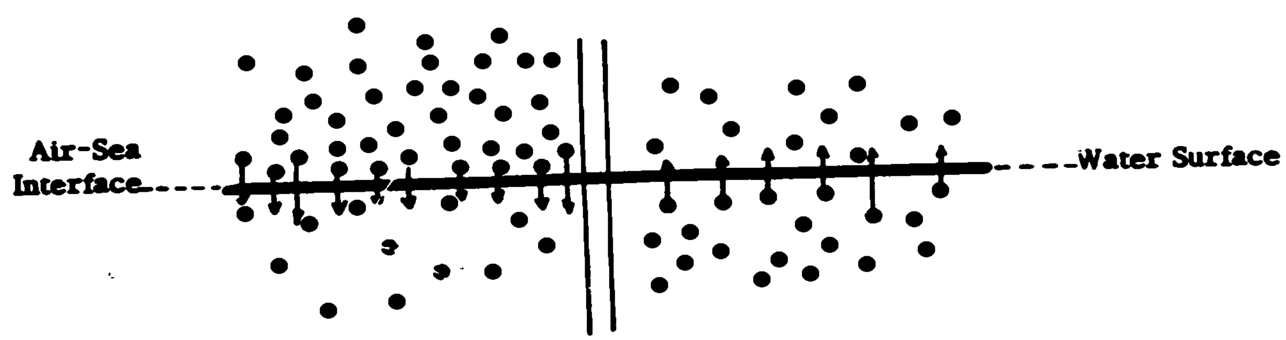


Figure 6 Air-Sea Interface Actions
● represents oxygen

There are three major sources of dissolved oxygen in the sea. The first source is oxygen from photosynthesis. The second is the exchange of oxygen at the air-sea interface (Figure 6). The third is the churning effect of the waves creating a great deal of aeration in the sea water.

Two methods are available for the determination of dissolved oxygen. The older Winkler (titration) method is a slow (titrating) technique, difficult at best to perform aboard a moving vessel. The second is the newer oxygen analyzer method. Using a sensor or standard cell and a electronic readout meter, the dissolved oxygen may be determined very quickly and accurately.

The results or amount of dissolved oxygen is expressed in one of the following ways: (1) parts of oxygen per thousand (ppt); (2) milligrams of oxygen per liter (Ml/L); (3) the percentage of oxygen in the water compared to the amount in the air (0/0). All of these units would be at a given temperature.

In the oxygen sensing element there is a silver and a gold electrode. These two electrodes are set at a given distance from each other. In order to have an electrical current flow or pass from one electrode to the other, dissolved oxygen must be present in the water. The more dissolved oxygen the greater the electrical flow. The amount of electrical flow between the two electrodes is measured by an electronic meter. Aboard the Floating Marine Laboratory we shall determine the oxygen in parts per thousand (ppm).

Often the oceanologist wishes to expand the data on oxygen. This may be done by converting the oxygen in parts per thousand to milliliters of oxygen per liter of sea

water or simply by multiplying the density of the sea water by the parts per thousand of oxygen. The density in the above may be obtained by using Knudsen's Hydrographic Tables.

pH AND THE MARINE ENVIRONMENT - The concept of pH is related to the concentration of hydrogen ions in solution. The oceanographer is interested in this information since it is related directly to the processes of photosynthesis and other chemical changes in the sea. Concentrations of hydrogen ions like salinity will affect the physiology of marine organisms.

One of the factors increasing the concentration of hydrogen ions is photo-synthesis. Algae can utilize the dissolved carbon dioxide (CO_2)of the atmosphere and also that given off by oxygen breathing organisms of the sea. There is, however, no free CO_2 in the water as it is generally combined into a fairly unstable carbonate molecule (HCO_3). An increase in the process of photosynthesis decreases the quantity of HCO_3 as CO_2 (carbon dioxide) As one of the molecules utilized in the photosynthetic process. When the carbonate molecule is reduced, hydrogen ions are released, and therefore, increased pH or concentration of H ions results. Most marine animals have a very narrow range of tolerance to changes in pH.

Sea water usually has a pH range between 6.7 and 7.4. This related to the pH scale which runs from pH 1, indicating acidity or large quantities of hydrogen atoms,

to pH 14 indicating a basic or alkaline condition or small quantities of hydrogen ions concentration,illustrates that sea water has a pH range from a little above neutral or basic to a little below or slightly acid.

A notable exception to this generality occurs along our coastal intertidal area. In the tide pools that are isolated for periods of time during low tides the algae consume nearly all the available CO_2 for the photosynthetic process and produce large quantities of hydrogen atoms causing the pool to become highly acetic.

SALINITY - Salinity S ‰ has been defined as the saltiness in the ocean. The salinity range in the ocean is 33 to 37 parts of dissolved salts per one thousand parts of water. Each specific area in the ocean has its own salinity range. The salinity will give the oceanologist a clue to the age of the water in that particular area. The higher the salinity the older the water. Also it tells the scientist what organismic life may or may not live within a given area. Therefore, salinity may be considered a limiting environmental factor. Basically organisms may be divided up into two types in regards to salinity. (1) The first type are those that may withstand only limited changes in salinity and are called <u>stenohaline</u>, an example would be the octopus. The organism's internal and external environment must always be in balance. If an organism migrates from an area of high salinity to one of low salinity its body cells tend to absorb more water. If an organism moves from a low to high salinity the opposite would occur. The result

would be the loss of water (dehydration) or gain water (imbibe) and the cells would literally burst. The net result in both cases would be the eventual death of the organisms. (2) The second type are those which may tolerate wide fluctuations in salinity and are called euryhaline organisms, an example of which would be the salmon. The excretory system is the organism's key system if normal water balance is to be maintained. As the organism migrates from high salinity to low salinity the excretory system will remove the excess water from the body tissue. With migration from low salinity to high salinity the excretory system must conserve fresh water to prevent dehydration within the body cells. If they do not, cells take in too much water and burst, killing the organism. The salmon has this problem to overcome when going to spawn. It moves into the mouth of a river from the ocean very slowly, thus allowing the cells to adjust and to secrete the extra water via the kidney.

Salinity may be determined by one of two methods. (1) The direct determination of salinity is accomplished by an instrument called a salinometer. The salinometer measures the electrical conductivity of the sea water, and provides the scientist with a direct salinity value. (2) The second method (modified Strickland and Parsons) used is an indirect process involving the titration or addition of silver nitrate ($AgNo_3$) and potassium chromate (K_2CrO_4) as a color indicator, to a sample of sea water. In the titration with silver nitrate the dissolved salts will react with the

silver to form a silver chloride precipitate (ppt). In the titration with sea water the number of milliliters (ml) of silver nitrate required to precipitate out all of the dissolved salts, may now be converted into units called chlorinity (Cl %•). (Chlorinity is defined as the amount of silver required to precipitate out all chlorides in a sample of sea water.) To determine the chlorinity the following expression is to be used.

$$\frac{\text{Cl \%• of an unknown sample}}{\text{Cl \%• of a known sample}} = \frac{\text{\# of ml of } AgNO_3 \text{ to ppt unknown}}{\text{\# of ml of } AgNO_3 \text{ to ppt known}}$$

By using Normal Sea Water (which has an accurate predetermined chlorinity) the chlorinity value for the known in the above expression is predetermined. Titrating with silver nitrate against the Normal Sea Water will give the number of milliliters required to precipitate out the chlorides. This titration with the Normal Sea Water has already been done for you and the information is posted on your team leaders direction sheets.

Salinity is related to chlorinity by the following expression:

$$\text{S \%•} = 0.03 + 1.805 \times \text{Cl \%•}$$

THE EKMAN CURRENT METER - For many years man has observed the phenomena of the surface currents. His curiosity was inceased by observing flotsam washed up on the beach which had its origin hundreds of miles away. A good example would be the Japanese glass fishing floats that are often found washed ashore along the California coast. Scientists

have been studying the surface currents by using drift bottles or cards. The cards are placed in a water-tight plastic envelope and released into the sea. Inside each bottle or envelope is a card asking the finder, in several languages, to fill in certain requested information in return for a small reward. Unfortunately, this is limited primarily to the surface currents.

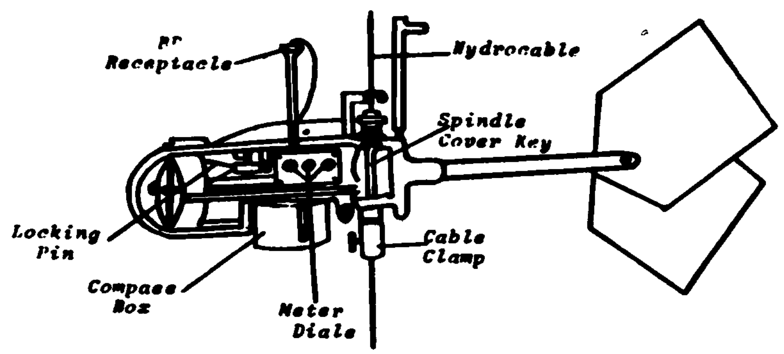


Figure 7

Currents below the surface are measured by the Eulerian method or the speed and direction of the water movement. For this the Ekman current meter is used. This is a multi-blade propeller, about 10 cm. in diameter, mounted on a low bearing in a framework which is attached to the end of a hydrocable (warp). The propeller drives a set of gears that record the number of revolutions made by the propeller. A fin or tail at the rear causes the propeller to point into the current. Before the meter is lowered into the water a spring pin is set against the blade preventing any recording before the instrument is at the desired depth. A messenger is sent down

the hydrocable tripping the pin allowing the propeller to begin recording the current movement. For a given length of time the propeller is allowed to turn. To stop the meter a second messenger is sent down and another pin stops the propeller. The meter is then pulled aboard and the number of revolutions are read from the meter. The speed of the current is directly proportional to the number of revolutions per minute.

This instrument also records the direction of the current. At the base of the meter is a round compass box which is divided into 10° sectors. In the box is a compass magnet with a grooved trough that remains fixed in relation to magnetic north. At intervals, while the propeller is turning, small bronze balls are released to fall to the top of the grooved trough, run down the trough and fall into one of the 10° sectors in the compass box. The compass and trough are always in a fixed position. Only the box moves allowing the balls to fall into the grooves indicating the current direction.

Aboard the Floating Marine Laboratory we will use an Ekman current meter. Caution must be taken to prevent the propeller blades from becoming entangled with materials in the water. One of the drawbacks of the Ekman current meter is it must be hauled out of the water after each measurement.

THE IMMEDIATE ENVIRONMENT II

THE BIOLOGICAL PROPERTIES OF THE OCEANS - You are probably more familiar with the biological aspects of the sea than you were with its physical properties. The abundance and variety of life the oceans support almost defies description. On today's cruise you will observe but a mere fraction of life in the sea.

The oceans can be divided into specific divisions relative to fairly stable boundaries based on light penetration and depth. The divisions based on light have been designated as the Photic Zones. The portion of the ocean in which light penetrates to the greatest degree and in which photosynthesis occurs, extends from the surface to a depth of about 80 meters is called the Euphotic Zone. Extending from the 80 meter boundary to about 200 meters, where light does not extend or penetrate abundently is called the Disphotic Zone. Finally, the area in which light is absent is called the Aphotic Zone. These divisions are verticle as compared to the next divisions which are horizontal.

The great ocean expanses are divided into two basic provinces, the Neritic and the Oceanic. The Neritic province extends from the intertidal zone out to about the edge of the Continental shelf or to a depth of about 200 meters. Beyond this lies the Oceanic province. All the water that covers these two provinces can be classified as the Palegic (an area where organism can float or swim freely). The Neritic province is characterized by supporting the most abundant life. It is the area that supports the attached plants such as the Giant Kelp Macrocystis as well as the major fisheries. The Oceanic province

is noted for its great expanse and great depth range, often referred to as the open ocean divisions.

Next is the Benthic Division. This classification refers to the life that is found on or near the bottom of the sea. Starting from the tide line the first subdivision is the Littoral zone which is subdivided into the Eulittoral, the area between the high and low tide marks, and the Sublittoral, the bottom or near bottom areas of the Continental Shelf. From the edge of the Continental Shelf and Continental Slope the Benthic division becomes the Deep-Sea system. This subdivision is divided into the Archibenthic and Abyssalbentic zones. These correspond to the near bottom or bottom organisms on the slope and Abyss respectively. (Figure 8)

The organisms that are found within these divisions are also classified. They are basically placed into three divisions:

1. Plankton are those forms that are the drifters and are at the mercy of the currents for locomotion. The planktonic organisms can be called the 'grass of the sea.' These are the free floating microscopic plants and animals that among other things are responsible for the colors of the sea. When you see clear blue water it indicates an ocean desert, or the lack of planktonic life. Plankton can be subdivided into two categories, the plant plankton or Phytoplankton and the animal plankton or Zooplankton. The phytoplankton are dependent upon sunlight for survival, since they are the photosynthysizers or primary producers.

2. The Nekton are the fish, whales, seals, sea turtles and some larger invertebrates such as the squid and shrimp. These organisms are capable of directed locomotion and can swim against the currents roaming over vast areas of ocean.

3. Benthos, or bottom dwellers represent the slow moving or sometimes sessile forms. In the coastal Littoral zones the chiton, barnacles or crabs, represent the Benthos. In the deeper abyss sea stars, urchins, snails, and bi-valves are examples. Figure 8 indicates the greatest depths at which Benthic organisms have been collected.

THE MARINE ENVIRONMENTS

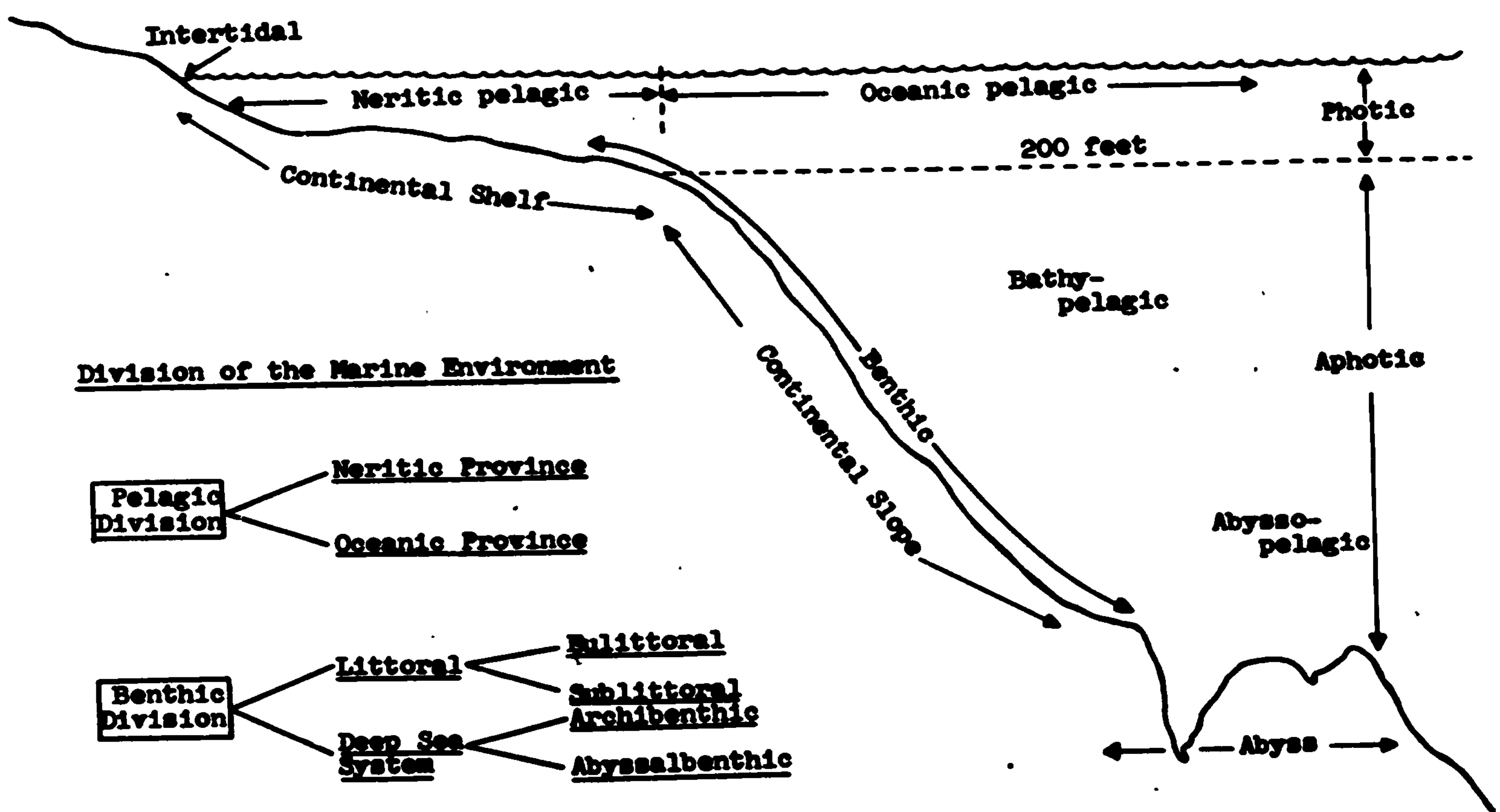


Figure 8

Figure 7

Greatest depths of distribution of various groups of bottom-living animals

Group	Depth m	Trench	Research Ship	Year
Forminifera	10,415-10,687*	Tonga	Vityaz	1957
Porifera	8,610-8,860	Kuril-Kamchatka	Vityaz	1953
Hydrozoa	8,210-8,300	Kermadec	Galathea	1952
Octocorallia	8,610-8,660	Kuril-Kamchatka	Vityaz	1953
Hexacorallia	10,630-10,710	Mariana	Vityaz	1958
Nemertini	7,210-7,230	Kuril-Kamchatka	Vityaz	1953
Nematoda	10,715-10,687	Tonga	Vityaz	1957
Polychaeta	10,630-10,710	Mariana	Vityaz	1958
Echiuroidea	10,190	Philippine	Galathea	1951
Priapuloidea	7,565-7,579	Japan	Vityaz	1957
Bryozoa	8,210-8,300	Kermadec	Galathea	1952
Brachipoda	5,730-5,458	Pacific Ocean	Vityaz	1957
Ostracoda	6,920-7,657	Bougainville	Vityaz	1957
Harpacticoida	9,995-10,002	Kermadec	Vityaz	1958
Cirripedia	6,960-7,000	Kermadec	Vityaz	1952
Tanaidacea	8,928-9,174	Kermadec	Vityaz	1958
Amphipoda	10,715-10,687	Tonga	Vityaz	1957
Isopoda	10,630-10,710	Mariana	Vityaz	1957
Cumaceae	7,974-8,006	Bougainville	Vityaz	1957
Mysidaceae	7,210-7,230	Kuril-Kamchatka	Vityaz	1953
Decapoda	5,300	Kermadec	Galathea	1952
Pantopoda	6,860	Kuril-Kamchatka	Vityaz	1953
Loricata	6,920-7,657	Bougainville	Vityaz	1957
Solenogasters	6,660-6,770	Kuril-Kamchatka	Vityaz	1953
Gastropoda	10,715-10,687	Tonga	Vityaz	1957
Scaphopoda	6,930-7,000	Javan	Galathea	1951
Bivalvia	10,715-10,687	Tonga	Vityaz	1957
Octopoda	8,100	Kuril-Kamchatka	Vityaz	1949
Asteroidea	7,587-7,614	Mariana	Vityaz	1955
Ophiuroidea	7,974-8,006	Bougainville	Vityaz	1957
Echinoidea	7,250-7,290	Banda Sea	Galathea	1951
Holothurioidea	10,630-10,710	Mariana	Vityaz	1958
Crinoidea	9,715-9,735	Idzu-Bonin	Vityaz	1956
Pogonophora	9,700-9,950	Kuril-Kamchatka	Vityaz	1953
Enteropneustra	8,100	Kuril-Kamchatka	Vityaz	1949
Ascidiae	7,210-7,230	Kuril-Kamchatka	Vityaz	1957
Pisces	7,565-7,579	Japan	Vityaz	1957
Sipunculoidea	8,210-8,300	Kermadec	Galathea	1952

* The depth at the beginning and end of the trawl.

-- from Zenkevitch, L.
<u>Biology of the Seas of the U.S.S.R.</u>
1963

Figure 9

METHODS OF SAMPLING THE BIOLOGICAL ENVIRONMENT

PLANKTON - Life in the sea may be conveniently divided into three categories; plankton (the passively drifting plants and animals), nekton (the actively swimming animals, not at the mercy of the currents), and benthos (organisms found living in or near the bottom). Two distinct types of plankton exist; the phytoplankton, or plant plankton, and the zooplankton, or animal plankton. The phytoplankton is equivalent to the green plants which surround us on land. As is true of land plants, the phytoplankters absorb the radiant energy of the sun and use this energy to synthesize essential body materials. The zooplankton are incapable of utilizing the sun's energy and must gain nutrient energy by feeding either on phytoplankters or on other zooplankters.

Man in his search for knowledge of the sea is very interested in its productivity. What is its potential food value? To partially answer this question, marine biologists use a piece of equipment called the plankton net. This is a cone-shaped small-mesh net that is towed behind a slowly moving vessel to collect the plankton.

On land the farmer determines the productivity of his acreage in terms of so many bushels of corn or wheat. In the sea man has devised another measure. By knowing the diameter of the plankton net mouth (opening) and the distance the net

will travel, you can roughly calculate the volume of water sampled by determining the volume of "this hypothetical?" cylinder. Then by taking a series of subsamples (equally divided portions of the sample) of the collected sample and counting the number of individuals within the final subsample, an estimate of the abundance of the zooplanktonic copepods (in terms of number per cubic meter of water) can be made.

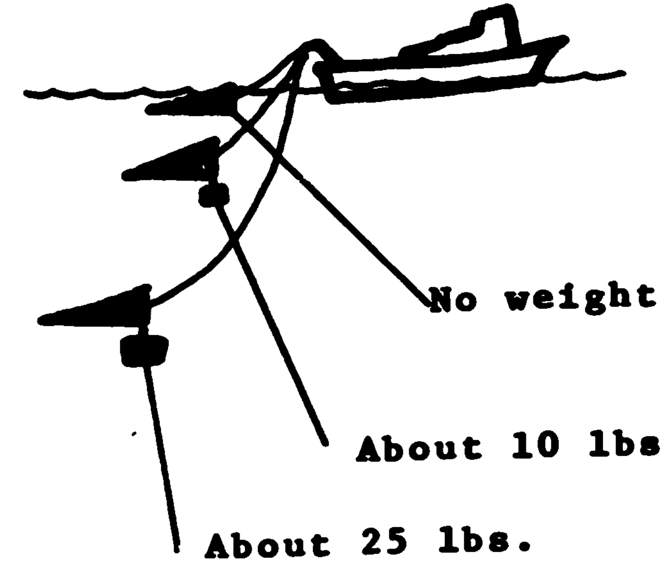
Plankton tows are made with either a fine grade (200 meshes to the inch) or a medium grade (125 meshes to the inch) net. At the end of the net a jar is tied and as the net is towed behind the boat at a distance of 25 to 50 feet the plankters are caught in the net and slowly pass into the jar as the water filters out of the net. By attaching a weight to the net, deep tows or sub-surface tows can also be made. (see sketch on next page) The tow itself should last a minimum of 10 minutes and the net should be lifted straight up into the boat, washed and held until all the water filters out. Then the jar should be removed from the net and capped.

Examination of the plankton can be made initially aboard the boat by use of a petri dish and a dissecting microscope. Further examination can be made with a microscope of higher magnification.

A. Procedure for towing the plankton net:

1. Prepare the net with the bottle for towing.
2. Indicate to the Captain when you want to commence the tow.

3. When the boat is moving slow enough, lower the net into the water and pay out the cable. Indicate this at the same time to the Captain so the chart can be marked for the distance determination.



4. Record the time for starting the tow.
5. The Captain will indicate to you when the distance has been reached.
6. Bring in the net; allow it to hang for a few minutes.
7. Wash all the plankton from the sides of the net into the collecting bottle by running water from the <u>outside</u> of the net.

B. Procedure for analysis of the plankton sample

1. Take the plankton sample to the laboratory and transfer it to the plankton splitter. Carefully wash the remaining plankton material from the sample jar into the plankton splitter with the squeeze bottle provided.

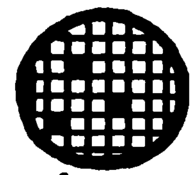
2. Note that the plankton splitter is separated into two halves. By tilting the splitter so that the sample is first in the open half and then in the divided half, the sample can be "split" into two equal parts of sub-samples. Drain the subsample from the portion of the splitter with a spigot into a beaker (again using the squeeze bottle to wash out any remaining material).

   Set this beaker aside. You will use this material later to identify the types of plankton collected.

3. Repeat step 2 until the amount of plankton remaining in the plankton 1/32 of the original amount. You are thus reducing the amount from 1 to 1/2 to 1/4 to 1/8 to 1/16 to 1/32.

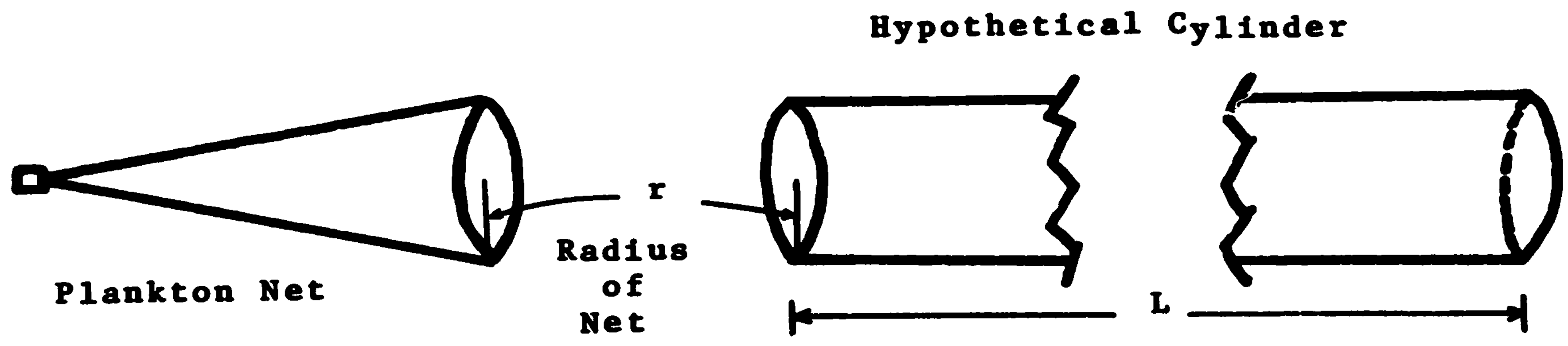
4. Transfer the final (1/32 "split") subsample to a grided petri dish. You must now estimate the number of copepods contained in this petri dish. Copepods are the most abundant and obvious representatives of the surface plankton and have the following general appearance:

Figure 10

5. The petri dish is subdivided into 25 squares. By counting the number of copepods in any one square and multiplying by 25, you <u>could</u> estimate the total number of copepods in the dish. If you did this, however, you would be showing "bias," that is, you would be selecting the square which you "wanted" to count. For this reason three squares have been "pre-selected" for you to count. Count the total number in the three squares indicated in the following drawing:  ; divide this total by three (you have now the "average" number per square); and multiply this number by 25 (giving you the number in the petri dish). This value represents 1/32 of the total number of copepods collected by the plankton net. What, then, is the total number of copepods collected?

6. It is of little value for us to know only the total number of individuals. We need to be able to say that a certain number of individuals is contained within a defined amount of space. For example, we would say that there are so many bushels of wheat per acre of land. Here we want to arrive at a value for the number of copepods per cubic meter of water. We must first determine the volume of water sampled

by the plankton net, as follows:



$$V = \pi r^2 L$$

where; V = volume (in cubic meters)

π = 3.1417

r^2 = radius of net, squared (in square meters)

L = towing distance or length (in meters)

7. Finally, by dividing the total number of copepods by the volume of water sampled,you will arrive at the number of copepods per cubic meter.

C. Identification of plankton

Return to the plankton sample set aside at step B 2. Transfer this material to petri dishes and slides for examination under the dissecting and compound microscopes.

As explained on page 24 the plankton is divisible into the phytoplankters and the zooplankters. Representatives of the phytoplankters found locally are illustrated on pages 65- 72. Note that two groups (the diatoms and dinoflagellates) make up the bulk of the phytoplankton. List the types which you find on page 85, Field Data Sheet - Plankton Summary.

The zooplankters can be broken down into those forms which are only found in the plankton (permanent zooplankters) and those forms which spend only the early phases of their life history in the plankton (temporary zooplankters). The permanent zooplankters are illustrated on page 67. List those which you find on page 85.

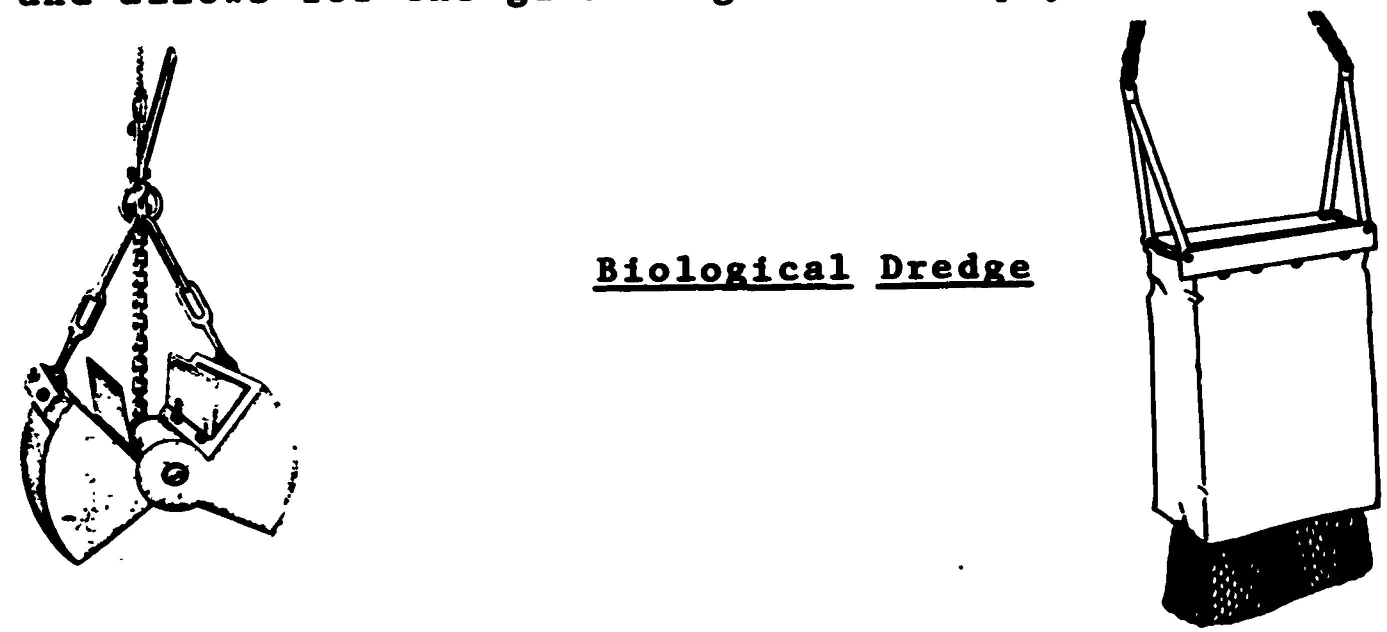
The temporary zooplankters are represented by the larvae from a great variety of bottom dwelling, or benthic, animals. The larvae are found in the plankton only at specific times of the year. In order that we might eventually know what types of larvae are found during which season of the year, the chart on page 85 was prepared. List the types of larvae you find under the appropriate season heading.

THE BIOLOGICAL GRAB - The dirt-digging device, or biological grab, is attached to a hydrocable and lowered into the ocean. When it hits the ocean bottom a triggering device is set off, and the jaws close picking up samples of the benthos. This sample is brought up to the deck of the boat and analyzed. The purpose of the grab is to obtain a small sample of bottom material from a non-rocky substrate at a specific location. This grab allows the scientist to determine exactly how much and type of material obtained along with how many and the kinds of organisms found living in these sediments. One of the major features of the bottom grab is that it allows the scientists to obtain material from an accurately fixed station. This accuracy is important for follow-up investigations to detect possible change in the area under study.

A second advantage of the grab is to obtain a <u>small</u> sample of the benthos, thus conserving the area. While on station the scientist may obtain other important data. Salinity, oxygen concentration, pH, temperature, depth, water movements and possibly the concentration of nutrient materials in the water can be correlated with the benthic population sampled. With this information the oceanologist is able to construct an environmental picture of the area sampled. To obtain more knowledge of the environment, the scientist may choose to attach to the grab either a television or a film camera.

THE BIOLOGICAL DREDGE - The biological dredge is a benthic (sampling) device that is towed behind a slow moving vessel over a given area. The front part of the dredge digs

into the substrate picking up (benthic) organisms. The purpose of the dredge is to enable the scientist to sample a larger or wider area than with a grab. It may also be used in rocky areas where the grab is unable to function properly. Materials sampled by the dredge move into a collecting bag where they remain until brought on board for analysis. Most biologists today use small dredges in order to pick up only those living organisms and materials that can be used in their studies. It is more difficult to obtain physical data such as salinity, oxygen concentrations, pH, while towing the dredge over a long distance with our present types of equipment. The lack of physical data could be considered a limitation if a complete environmental composite were to be constructed. However, it should be noted that the biological dredge and the biological grab perform specific functions. The dredge, being a more general instrument, is used to sample long, narrow areas, thereby producing a general environmental picture. The grab samples a specific area in greater detail and allows for the gathering of other physical data at the same time. (Figure 11)



Peterson Grab

Biological Dredge

Figure 11

THE TRAWL - The trawl is a balloon-like net which is towed behind a vessel. It is used in the pelagic fisheries industry and by the marine biologist to sample fish populations. The size of the trawl net varies according to the size of the fish to be sampled and the size of the vessel which will tow it. The net is held open by two doors, one on each side, as shown in Figure 12. The trawl may be positioned so it can sample the bottom or anywhere above the bottom by adjusting the length of the warp (towline) and the speed of the vessel. The two basic types of trawl are the (1) bottom trawl and (2) mid-water trawl.

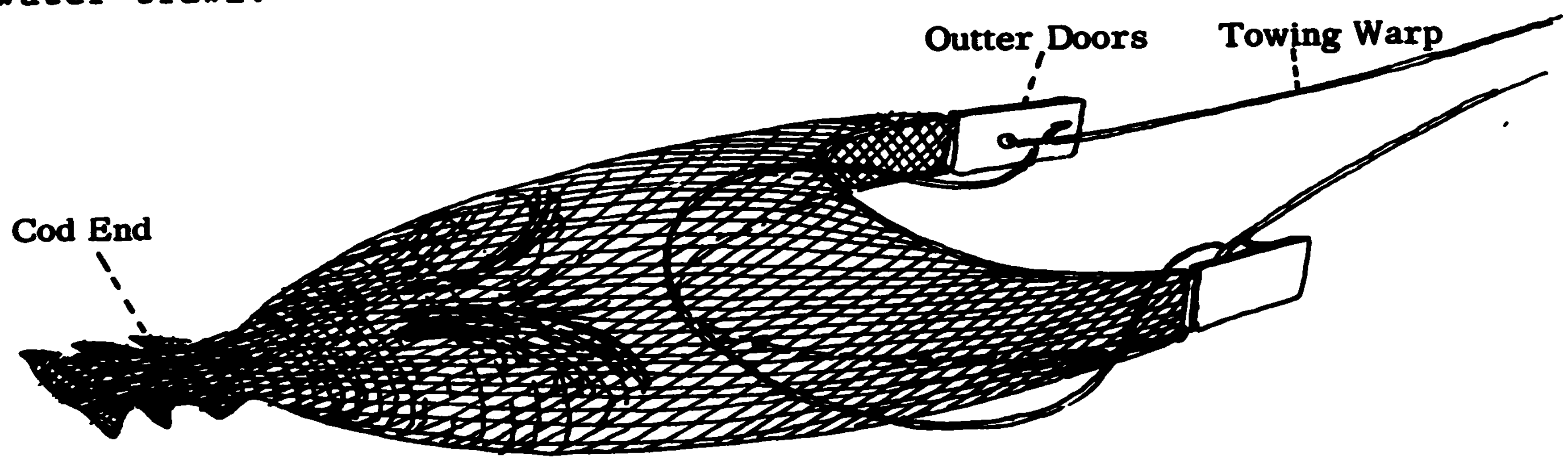


Figure 12 Trawl Net

Aboard the Floating Marine Laboratory we use the bottom trawl. It measures 16 feet across at the opening and the diameter narrows as the net approaches the bag or codend. The net is lowered and towed for a period of time. The location and course of each trawl is carefully noted. This serves two purposes. First it allows the scientist to plot on

a map where the sample was taken. Secondly, it serves to remind him not to re-trawl in the area too soon, thus preventing the destruction of bottom materials and living organisms. After the trawl has been towed for a given period of time, it is pulled aboard, the codend is then untied and the specimens carefully removed from the bag and deposited into the holding bins. Aboard the Floating Marine Laboratory, if too large a sample is collected, the greater part of the living material is placed back into the sea immediately for the conservation of life. The scientist samples only enough to obtain adequate data to construct a biological picture of the area sampled. The fish are counted and classified. Each fish is measured for length and any other data taken which may be needed. Data such as the size and numbers of fish for a given species provides information on the productivity in that area. The trawl produces, on occasion, invertebrates which are counted, classified and measured.

DETERMINATION OF THE PENETRATION OF LIGHT BY MEANS OF A SECCHI DISC - The Secchi Disc has been widely used as an instrument for measuring water clarity, the amount of light that enters the sea. The abundance of microscopic plants (phytoplankton) is directly related to the amount of light that penetrates the water which in turn determines the number of animals found in the same water that depend on the phytoplankton for food.

Everywhere in the oceans of the world suspended particles of living or non-living matter scatter the radiation (energy). The amount of solar radiation entering the water decreases with its passage downward through absorption and because of this scattering. Water that is not clear (turbid) absorbs more energy (radiation) and increases temper-

ature.

Much of the radiation is absorbed very quickly, some 62 per cent in the first meter in clearest water and much more in coastal or turbid waters. Sea water is translucent and penetrable for the wave lengths that are most useful for plants to carry out photosynthesis. Infrared and ultraviolet generally do not penetrate beyond 10 meters while the blue-green wavelengths go well beyond the 100 meter mark.

The familiar blue color of the deep sea is due to the scattering among water molecules of the light frequencies (radiation) and is, therefore, comparable to the blue of the sky. Thus, the "blueness" of the oceans is indicative of "deserts" and the turbid oceans, of "forests."

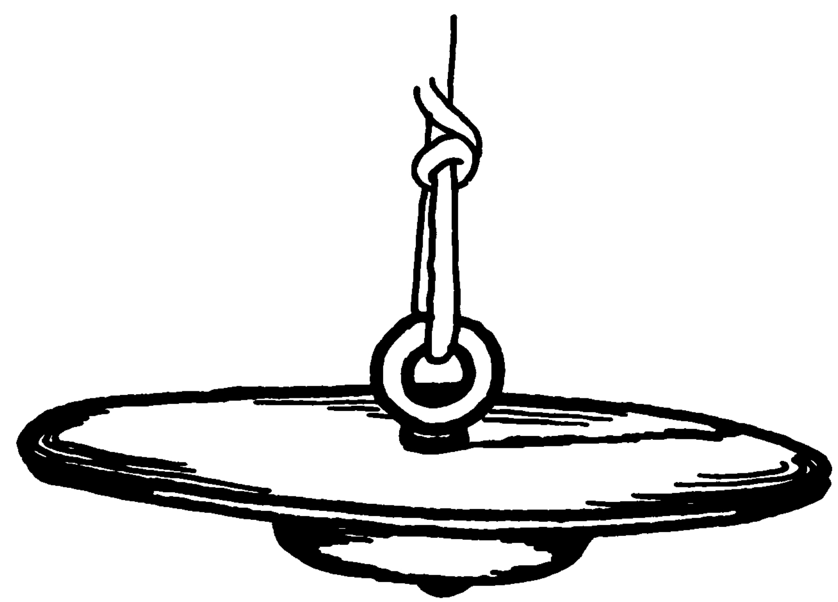


Figure 13 Secchi Disc

HOW TO USE A "KEY" - One of the purposes of the marine scientist is to search out and collect the organisms of the environment and to properly place them in the overall scheme of diversity in the biological world. The biologists who are concerned with this enormous task are called taxonomists or systematists. They are interested in classifying and placing in their proper evolutionary relationships the plants and animals found in this environment.

Classification is based on an organism's morphology (form and structure), and the organisms are grouped according to similarities of structures. For instances, porpoises, whales, bats and man all belong to a large group, the mammals, based on several features, among which are covering of hair, warm blood, and nourishment of newborn with milk. We can show an organism's relationship and identify its scientific species by using external features.

Biologists have devised a "key" using the organisms' external features. For instance, in the fish we can use the presence or absence of anal spines as a key characteristic. Another would be the shape of the caudal fin, whether or not the tail was symmetrical or asymmetrical, evenly divided or uneven, rounded or forked, and so forth.

We use these key features or characteristics in various combinations to set apart particular groups of fish. Each group of organisms has its own peculiar set of key characteristics. By taking each of a series of characteristics and determining if the specimen in question does or does not have a particular set, we can work our way through a key to derive the organisms correct identity. A key in which you have an alternate

choice of features is called a dichotomous key. The word dichotomous means "separated into two parts."

Turn to "A Key To The Common Fishes Collected From The Floating Laboratory" for a key that is based on the external features of fish. The starting point of differentiating groups is between sharks and bony fish. By simply saying yes or no to (A) you can stop or move ahead according to the specimen with which you are working.

A more sophisticated key does not usually have pictures. It is based on external features appearing as cuplet (alternate choices, either yes or no). At the end of each statement appears a series of dots and a number, a name, or group of names. The number tells you the next cuplet to read in order to proceed ahead. A name indicates the appropriate classification.

For example:

1. Mouth a sucking disk, no jaws 2
   Mouth normal, jaws well developed 3

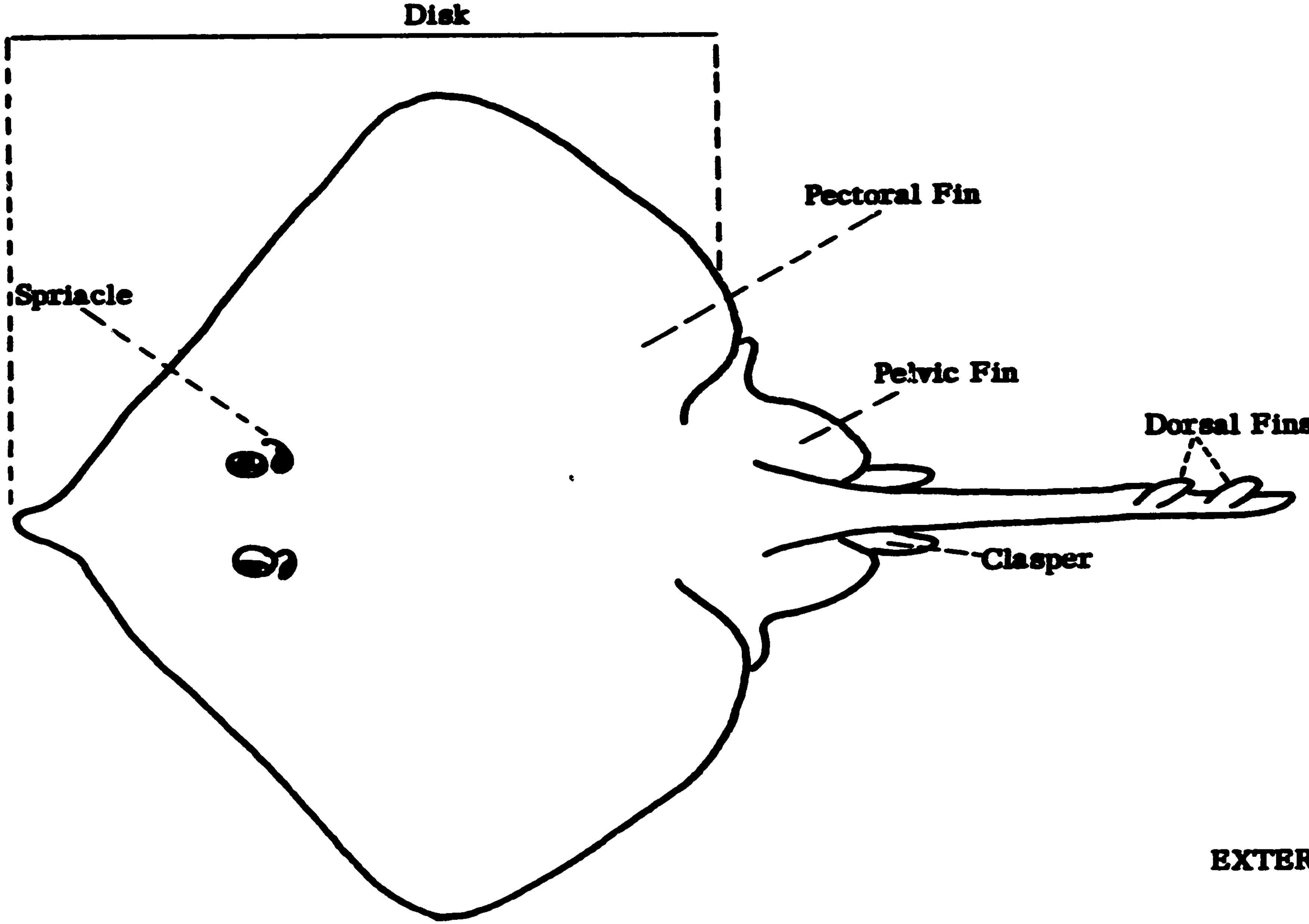
2. Gill openings 10 or more on each side. Hagfish, family Eptratretidae
   Gill openings 7 on each side. Lamprey, family Petromyzontidae

3. External gill openings 5 to 7. Shark or ray.
   External gill openings 1 4

4. Eye on each side of head 5
   Both eyes on same side of head. Flat fish

5. Pelvic fins present 6
   Pelvic fins absent. Refer to key

In order to achieve maximum use of a key, the student must become familiar with the external features of the organism in question.



EXTERNAL PARTS OF A SHARK

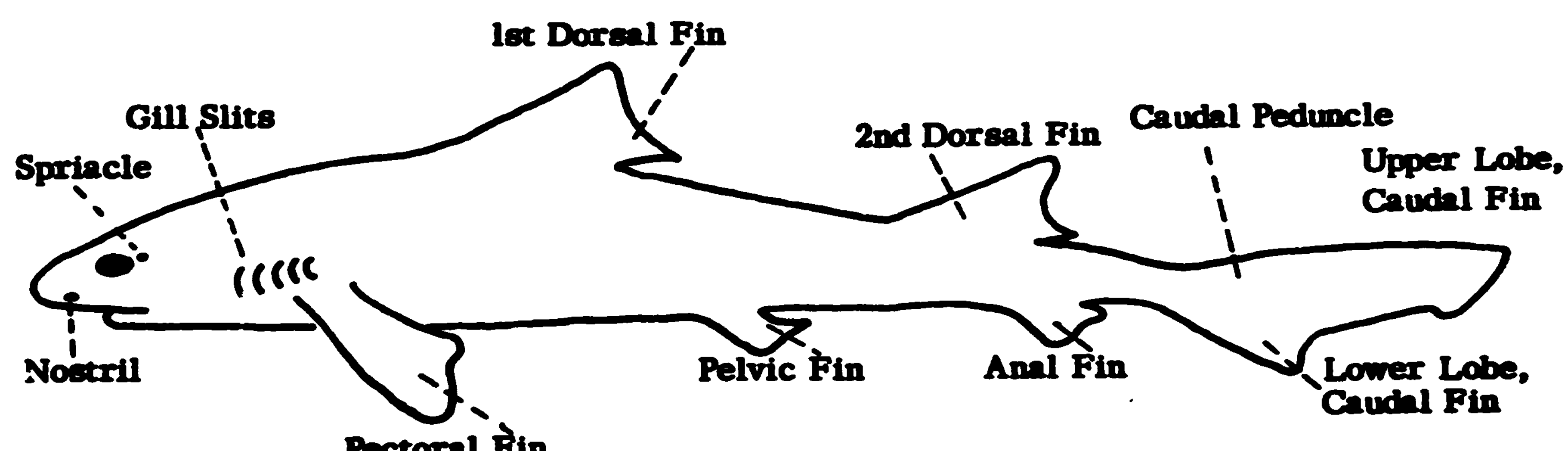


Figure 14

THE EXTERNAL PARTS OF FISHES

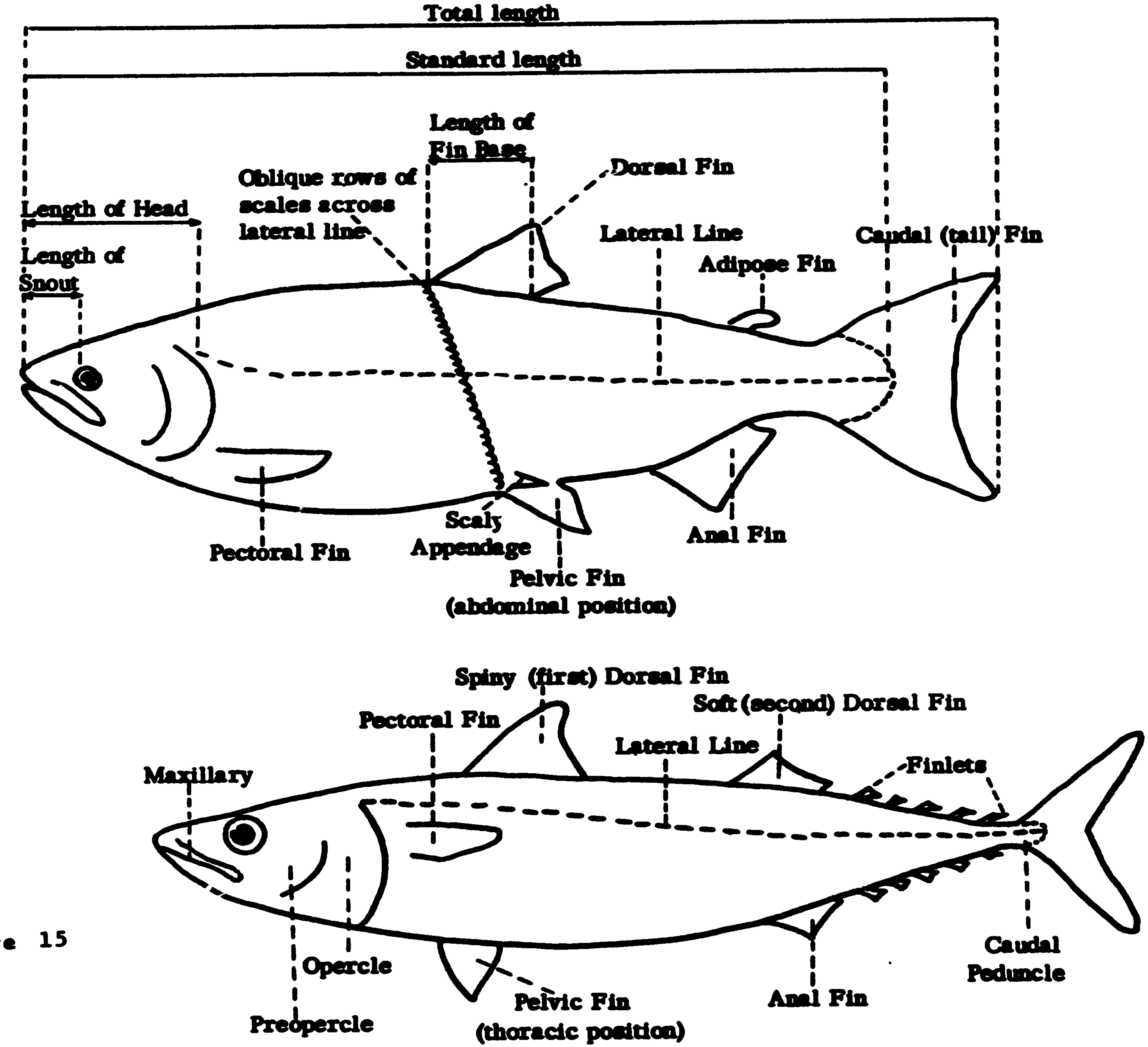
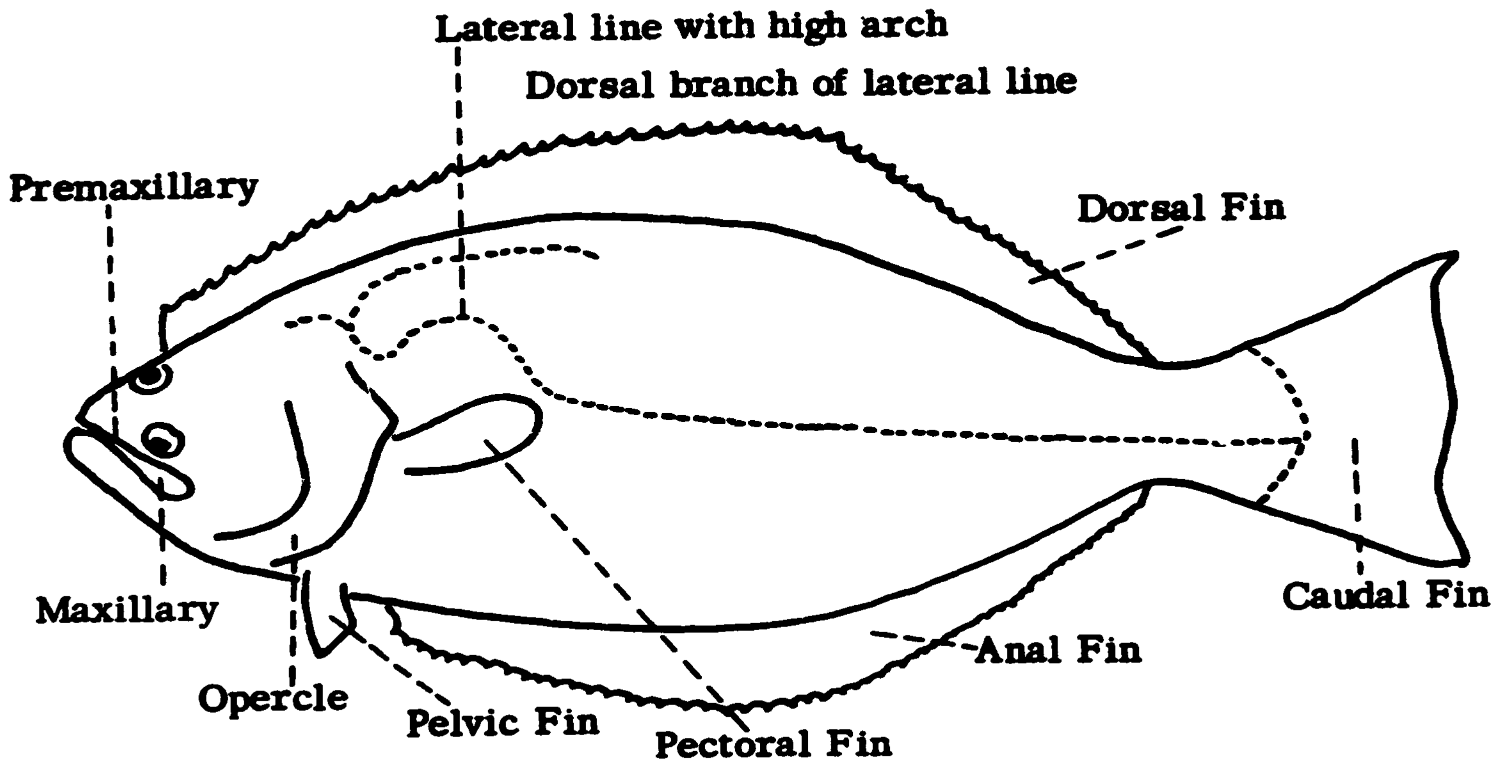


Figure 15



A HYPOTHETICAL FLATFISH

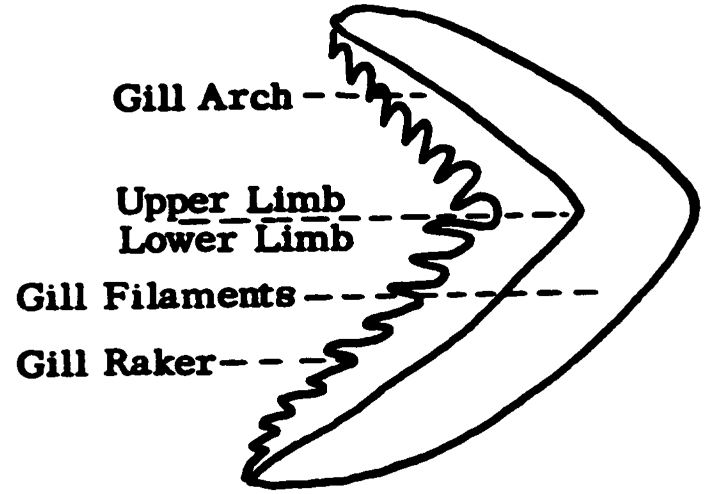


DIAGRAM OF A GILL ARCH

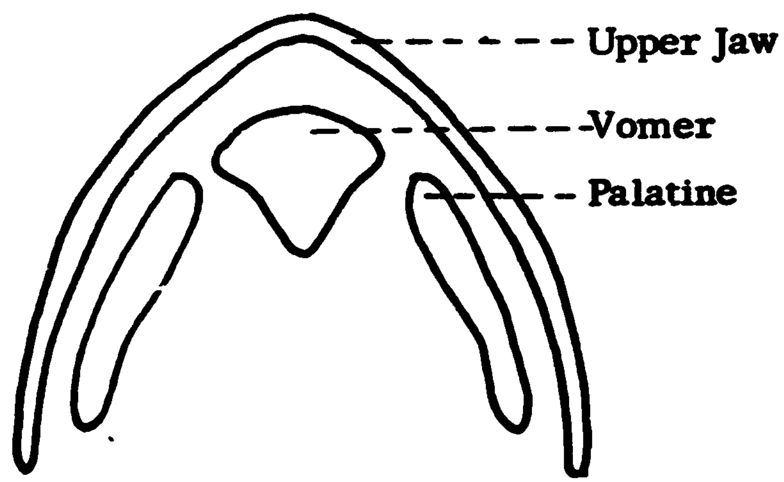


DIAGRAM OF THE ROOF OF A FISH'S MOUTH SHOWING THE BONES WHICH MAY BEAR TEETH

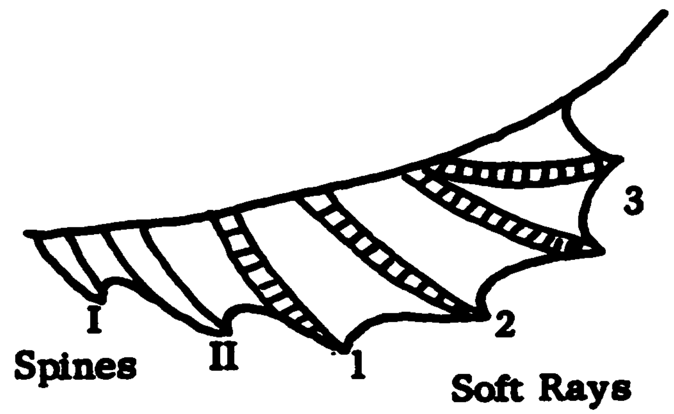
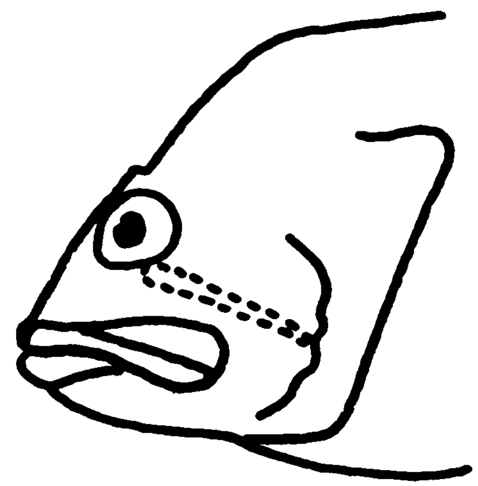


DIAGRAM OF A FIN SHOWING SPINES AND SOFT RAYS



POSITION OF THE BONY STAY FOUND IN SOME FISHES

Figure 16

EXTERNAL ANATOMY OF THE ANCHOVY

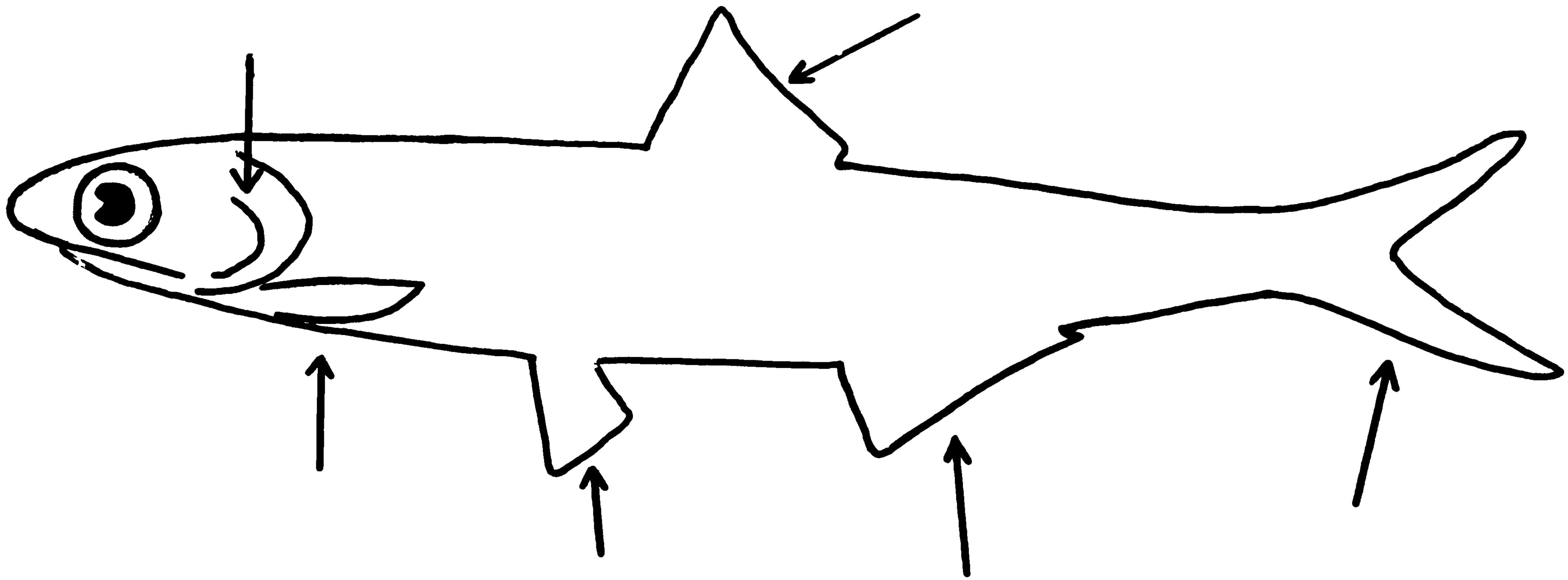


Figure 17 NORTHERN ANCHOVY (<u>Engraulis</u> <u>mordax</u> Girard)

INTERNAL ORGANS OF A TYPICAL FISH

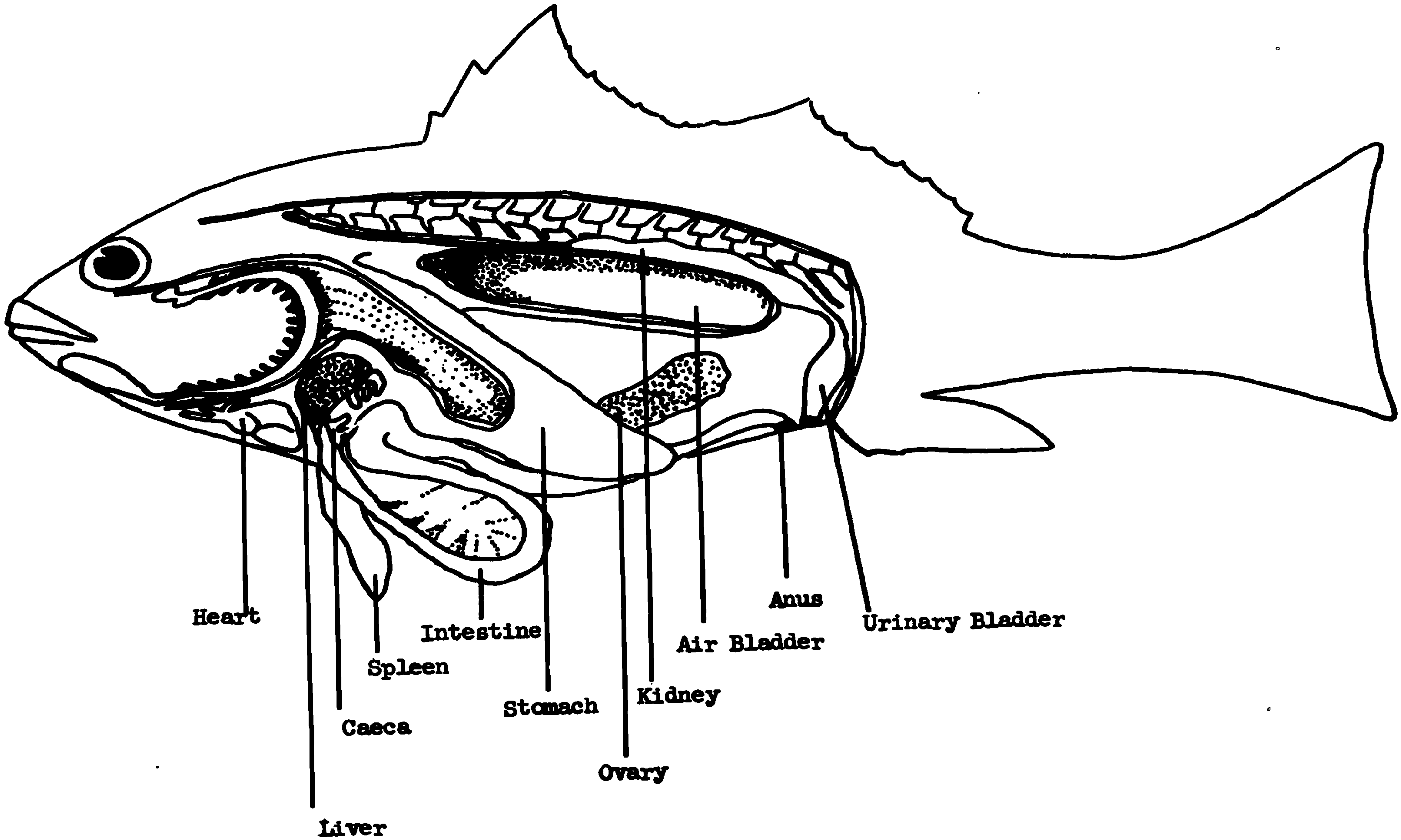


Figure 18

PROVISIONAL SPECIES LIST

By

David W. Valentine

SHARKS, RAYS, SKATES & CHIMAERAS

Family Name Scientific	*Family Name Common*	*Number of Species in California*	*Which Species Did You Collect Today?*
CHARCHARINIDAE	Requieum Sharks	(11)	
Mustelus californicus	Gray Smoothhound		
Triakis henlei	Brown Smoothound		
Triakis semifasciata	Leopard Shark		
CHIMAERIDAE	Chimaeras	(1)	
Hydrolagus colliei	Ratfish		
DASYATIDAE	Stingrays	(4)	
Gymnura marmorata	California Butterfly Ray		
Urolophus halleri	Round Stingray		
HETERODONTIDAE	Horn Sharks	(1)	
Heterodontus francisci	Horn Shark		
MYLIOBATIDAE	Eagle Rays	(1)	
Myliobatis californicus	Bat Stingray		

SHARKS, RAYS, SKATES & CHIMAERAS (continued)

RHINOBATIDAE	Guitarfishes	(3)
Platyrhinoidis triseriata	Thornback	
Rhinobatus productus	Shovelnose Guitarfish	
Zapteryx exasperata	Banded Guitarfish	
SCYLIORHINIDAE	Cat Sharks	(3)
Cephaloscyllium uter	Swell Shark	
SQUALIDAE	Dogfish Sharks	(3)
Squalus acanthias	Spiny Dogfish	
SQUATINIDAE	Angel Sharks	(1)
Squatina californica	Calfiornia Angel Shark	
TORPEDINIDAE	Electric Rays	(1)
Torpedo californica	Pacific Electric Ray	

BONY FISHES

AGONIDAE	Poachers and Alligatorfishes	(24)
Agonopsis emmelane	Northern Spearnose Poacher	
Odontopyxis trispinosa	Pygmy Poacher	
Xeneretmus triacanthus	Bluespotted Poacher	
ARGENTINIDAE	Agentines	(1)
Argentina Sialis	Pacific argentine	

ATHERINIDAE	Silversides	(3)
Atherinops affinis	Topsmelt	
Atherinopsis californiensis	Jacksmelt	
Leuresthes tenuis	California Grunion	
BATHYMASTERDAE	Rongquils	(5)
Rathbunella hypoplectrus	Smooth rongquil	
BATRACHOIDIDAS	Toadfishes	(2)
Porichthys myriaster	Slim Midshipman	
Porichthys notatus	Norther Midshipman	
BOTHIDAE	Lefteyed flounders	(6)
Citharichthys sordidus	Pacific Sanddab	
Citharichthys stigmaeus	Speckled Sanddab	
Citharichthys xanthostigma	Longfin Sanddab	
Hippoglossina stomata	Bigmouth Sole	
Paralichthys californicus	California Halibut	
Xystreurys liolepis	Fantail Sole	
BRANCHIOSTEGIDAE	Tilefishes	(1)
Caulolatilus princeps	Ocean whitefish	
CLINIDAE	Clinids	(12)
Gibbonsia elegans	Spotted Kelpfish	
Heterostichus rostratus	Giant Kelpfish	
Neoclinus blanchardi	Sarcastic Fringehead	
Neoclinus uninotatus	Onespot Fringehead	

COTTIDAE	Sculpins	(60)
Chitonotus pugetensis	Roughback Sculpin	
Icelinus filamentosus	Threadfin Sculpin	
Icelinus quadriseriatus	Yellowchin Sculpin	
Leptocottus armatus	Pacific Staghorn Sculpin	
Scorpaenichthys marmoratus	Cabezon	
CYNOGLOSSIADAE	Tonguefishes	(1)
Symphurus atricauda	California Tonguefish	
EMBIOTOCIDAE	Surfperches	(19)
Amphistichus argenteus	Barred Surfperch	
Cymatogaster aggregata	Shiner Perch	
Embiotoca jacksoni	Black Perch	
Hyperprosopon argenteum	Walleye Surfperch	
Hypsurus caryi	Rainbow Surfperch	
Micrometrus aurora	Reef Perch	
Micrometrus minimus	Dwarf Perch	
Phanerodon atripes	Sharpnose Seaperch	
Phanerodon furcatus	White Seaperch	
Rhacochilus toxotes	Rubberlip Seaperch	
Rhacochilus vacca	Pile Perch	
Zalembius rosaceus	Pink Seaperch	
ENGRAULIDAE	Anchovies	(5)
Anchoa compressa	Deepbody Anchovy	
Engraulis mordax	Northern Anchovy	
GADIDAE	Codfishes and Hakes	(6)
Merluccius productus	Pacific hake	

GIRELLIDAE	Nibblers	(1)
Girella nigricans	Opaleye	
GOBIIDAE	Gobies	(12)
Coryphopterus nicholsi	Bluespot Goby	
Lepidogobius lepidus	Bay Goby	
HEXAGRAMMIDAE	Greenlings	(7)
Hexagrammos decagrammus	Kelp Greenling	
Oxylebius pictus	Painted Greenling	
LABRIDAE	Wrasses	(3)
Oxyjulis californica	Senorita	
Halichoeres semicinctus	Rock Wrasse	
OPHIDIIDAE	Cusk Eels	(3)
Otophidium scrippsae	Basketweave Cusk-eel	
Otophidium taylori	Spotted Cusk-eel	
PLEURONECTIDAE	Righteye Flounders	(23)
Glyptocephalus zachirus	Rex Sole	
Hypsopsetta guttulata	Diamond Turbot	
Isopsetta isolepis	Scalyfin Sole	
Lyopsetta exilis	Slender Sole	
Microstomus pacificus	Dover Sole	
Parophys vetulus	English Sole	
Pleuronichthys coenosus	C-O Turbot	
Pleuronichthys decurrens	Curlfin Turbot	
Pleuronichthys ritteri	Spotted Turbot	
Pleuronichthys verticalis	Hornyhead Turbot	

POMACENTRIADAE	Damselfishes	(2)
Hypsypops rubicunda	Garibaldi	
SCIAENDIADAE	Drums	(11)
Cheilotrema saturnum	Black Croaker	
Genyonemus lineatus	White Croaker	
Menticirrhus undulatus	California Corbina	
Roncador stearnsi	Spotfin Croaker	
Seriphus politus	Queenfish	
Umbrina roncador	Yellowfin Croaker	
SCORPAENIDAE	Scorpionfishes & Rockfishes	(54)
Scorpaena guttuta	California Scorpionfish	
Sebastodes atrovirens	Kelp Rockfish	
Sebastodes auriculatus	Brown Rockfish	
Sebastodes dalli	Calico Rockfish	
Sebastodes elongatus	Greenstripe Rockfish	
Sebastodes entomelas	Widow Rockfish	
Sebastodes flavidus	Yellowtail Rockfish	
Sebastodes gilli	Bronzespotted Rockfish	
Sebastodes levis	Cow Rockfish	
Sebastodes miniatus	Vermilion Rockfish	
Sebastodes mystinus	Blue Rockfish	
Sebastodes paucispinis	Boacaccio	
Sebastodes Proriger	Redstripe Rockfish	
Sebastodes rosaceus	Rosy Rockfish	
Sebastodes rubrivinctus	Flag Rockfish	
Sebastodes saxicola	Stripetail Rockfish	
Sebastodes semicinctus	Halfbanded Rockfish	
Sebastodes serranoides	Olive Rockfish	
Sebastodes zacentrus	Sharpchin Rockfish	
SCORPIDAE	Halfmoons	(1)
Medialuna califoriensis	Halfmoon	

<u>SERRANIDAE</u>	Sea Basses	(6)
<u>Paralabrax</u> <u>clathratus</u>	Kelp Bass	
<u>Paralabrax</u> <u>maculatofasciatus</u>	Spotted San Bass	
<u>Paralabrax</u> <u>nebulifer</u>	Sand Bass	
<u>Stereolepis</u> <u>gigas</u>	Giant Sea Bas	
<u>STROMATEIDAE</u>	Butterfish	(4)
<u>Palometa</u> <u>simillima</u>	California Pompano	
<u>SYNGNATHIDAE</u>	Pipefishes and Seahorses	(6)
<u>Syngnathus</u> <u>auliscus</u>	Barred Pipefish	
<u>Syngnathus</u> <u>californiensis</u>	Kelp Pipefish	
<u>Syngnathus</u> <u>griseolineatus</u>	Bay Pipefish	
<u>SYNODONTIDAE</u>	Lizardfishes	(1)
<u>Synodus</u> <u>lucioceps</u>	California Lizardfish	
<u>TRACHIPTERIDAE</u>	Ribbonfishes	
<u>Trachipterus</u> <u>altivelas</u>	King-of-the-salmon	
<u>ZANIOLEPIDAE</u>	Combfishes	(2)
<u>Zaniolepis</u> <u>frenata</u>	Shortspine Combfish	
<u>Zaniolepis</u> <u>latipinnis</u>	Longspine Combfish	
<u>ZOARCIDAE</u>	Eelpouts	(10)
<u>Aprodon</u> <u>cortezianus</u>	Bigfin Eelpout	
<u>Lycodes</u> <u>Grevipes</u>	Shortfin Eelpout	
<u>Lycodopsis</u> <u>Pacifica</u>	Blackbelly Eelpout	

COMMON WATER AND SHORE BIRDS IN CALIFORNIA

COMMON WATER AND SHORE BIRDS IN CALIFORNIA

Check Time Seen	WHERE USUALLY SEEN-Size	GENERAL BODY COLOR	CHARACTERISTIC MARKINGS	REMARKS	BILL	LEGS AND FEET
* 1 Grebe, Eared..W.V.	1 On ponds, lagoons, or ocean..............M.	1 Dark gray above, white below.	1 White patch on cheeks and in each wing. In summer head is black and crested with a tuft of yellowish feathers on each side.	1-3 Expert divers, sometimes called "Hell Divers." All grebes commonly leap forward and then dive head first.	1 Slender, black, longer than head.	Lobed webs.
* 2 Horned Greve..W.V.	2 Bays...............S.	2 Head black, neck and flanks rufous red. Winter plumage contrastingly gray and white. Top of head, line down back of neck and back dark gray. Underparts, neck and chest clear white. Well defined.	2 Conspicuous buff-colored ear-tufts	2 Typically found on lakes, bays.	2 Dark bill.	" "
* 3 Grebe, Western.W.V.	3 On the ocean.......L.	3 Black above, white below.	3 The contrast of black and white is conspicuous.	3 Neck long and slender.	3 Slender, yellow, longer than head.	" "
* 4 Common Loon....W.V.	4 Ocean or bays......L.	4 Head and neck glossy black with white collar, under parts white Winter, mostly grayish.	4 Back checkered with black and white.	4 Largest of loons, stouter bill. Fly with legs trailing out behind.	4 Stout, straight top and bottom equal in size.	Large, project behind in flight.
* 5 Pacific Loon.....R.	5 Ocean and bays.....M.	5 Grayish in Winter.	5 Gray hind neck and black throat	5 Similar in size to Red-throated loon. Back often appears scaly-like.	5 Shorter and not as heavy as common loon	" "
* 6 Red-Throated Loon.............R.	6 Ocean and bays.....M.	6 Grayish and white winter plumage. Gray head and rufous-red throat, back speckled with white.	6 Red throat, gray on head and hind neck pale merging into white.	6 Smaller than common loon. Does not exhibit black and white contrast as in the other two loons.	6 Medium and <u>upturned</u>. This is one of the best field marks to identify this bird.	" "
* 7 Pelican, Brown...R.	7 On ocean or bays ..................V.L.	7 In winter, brownish above and below; in summer, gray streaked with brown above, brown below.	7 Mature birds with white on top of head and neck.	7 Dive into water with a splash when fishing.	7 Huge, yellow above, gray below.	Webbed between all four toes.
‡ 8 Cormorant, Double-crested..........R.	8 On ocean, bays or inland.............L.	8 Black. Immature brownish.	8 Throat pouch naked, orange.	8-10 Cormorants have long slender necks, wings set far back on body, and a short tail. Fly with bill held at an upward angle.	8-10 Cormorants have bills as long as or longer than head.	" "
‡ 9 Cormorant, Brant's	9 On ocean or bays, never inland.......L.	9 " " "	9 " " " , blue.			" "
‡ 10 Cormorant, Pelagic	10 On ocean or bays, never inland.......L. Smaller than others.	10 " " "	10 " " " , red; white patch in each wing in spring.	10 Rare in Southern California		" "
SEA OR DIVING DUCKS						
† 11 Redhead........W.V.	11 Found in ponds, lagoons, etc., or ocean	11 Red head and neck, gray back & flanks. Female uniform brown	11 Black on breast and tail. Female has gray area on edge of wings.	11 Rounded head.	11 Bluish-gray with black tip.	Grayish.
† 12 Canvasback.....W.V.	12 " " "	12 Red head and neck, white back and flanks. Female with brownish head, gray back and flanks.	12 Breast black. Female has brown breast.	12 Long low sloping forehead and long bill are diagnostic.	12 Black	"

* Protected at all time
† Open season at certain times
‡ Not protected in California
R Resident

V.L. - Very Large (30 inches or more)
L. - Large (about the size of a Mallard Duck, 20-25 inches)
M. - Medium
S. - Small

V.S. - Very Small
S.V. - Summer Visitor
W.V. - Winter Visitor

Check Time Seen	WHERE USUALLY SEEN-Size	GENERAL BODY COLOR	CHARACTERISTIC MARKINGS	REMARKS	BILL	LEGS AND FEET
SEA OR DIVING DUCKS Continued						
† 13 Lesser Scaup Duck or Bluebill.....W.V.	13 Found in ponds, lagoons, etc., or ocean	13 Head and breast black, lower back and flanks white. Female brownish with white abdomen.	13 Speculum white in both sexes. Female has white area at base of bill.	13 Purplish reflections on head of male. Eyes yellow.	13 Bluish.	Black.
† 14 Scoter , White-winged..........W.V.	14 Mostly seen on the ocean..............L.	14 Black. Female solid dark brown.	14 Large white patch in wing. Male has white blotch behind eye. Female has white blotch behind eye and another in front of eye.	14 Scoters are large heavy birds with swollen bills and long sloping.	14 Orange in male, dusky in female.	Black and flesh color or orange.
† 15 Scoter, Surf....W.V.	15 " " " "	15 " " " " " "	15 White patch on forehead and back of neck. Female has white patch below eye and another in front of eye.	15 " " " " "	15 " " "	" " "
*16 Red-breasted Merganser.........R.	16 Oceans or bays.....M.	16 Greenish-black head, broad white collar on neck, breast reddish-brown streaked with black.	16 Conspicuous crest, breast brownish at water line.	16 One of the medium sized fish ducks, light area between eye and bill sharply defined.	16 Red.	Orange.
*17 Red Phalarope...W.V.	17 On ocean or bay....S.	17 Gray and white.	17 Characteristic "phalarope-mark" through eye. White wing mark gray crest with darker gray on sides forming a partial breast band.	17 Most maritime of the species.	17 Heavy, needle-like bill.	Yellowish.
GULLS						
*18 Glaucous-winged Gull............W.V.	18 On any body of water on or near the coast, beaches, etc.......L.	18-23 Immature gulls have uniform dark plumage the first year; mottled, the second.	18 Head, neck and breast white in summer, washed with dark gray in winter.	18-23 Wings long. 18 This is the only gull we have which has no black on wing tips.	18-23 Bill thickened, the upper mandible longer and hooked. 18 Light yellow with red spot on lower mandible.	Webbed between 3 of the 4 toes.
*19 Western Gull......R.	19 Water front, beaches, ponds, etc.........L.	19 Back dark gray, under parts white.	19 Head, neck and breast white, wings black tipped, edged with white.	19 The only gull with us in winter having a pure white head and neck.	19 Deep yellow with red spot on lower mandible.	Pinkish.
*20 California Gull.W.V.	20 Water front, beaches, ponds, bays, lawns and inland.........M.	20 Back bluish-gray, under parts white.	20 Head, neck and breast white in summer, streaked dusky in winter, wings tipped with black.	20 One of our most common gulls.	20 Yellow with red spot on lower mandible and a black spot in front of this.	Greenish.
*21 Ring-billed Gull............W.V.	21 " " " "	21 Back light gray, under parts white.	21 " " " " " "	21 Lighter gray than the California Gull and more agile.	21 Yellow with a black ring near tip.	Yellow.
*22 Heermann's Gull..W.V.	22 Water front, beaches, bays, lagoons......M.	22 Back deep grayish-black, under parts gray.	22 Head and upper neck white in summer, grayish-brown in winter; tail black, tipped with white.	22 Our darkest gull. The red bill is distinctive.	22 Red tipped with black.	Black.
*23 Bonaparte's Gull............W.V.	23 Water front, beaches, ponds, etc.........S.	23 Back light gray, under parts white.	23 Head with black hood in summer, white in winter with a dark spot before eye and another back of eye. Large patch of white in outer part of wing, this edged with black.	23 Our smallest gull.	23 Black.	Orange-red.
TERNS						
*24 Forster's Tern ........W.V. or S.V.	24 Ocean shores, lagoons ponds, marshes, irrigation areas, etc.................M.	24 Back pearl gray under parts white.	24 Top of head black in summer, white in winter with a black stripe from bill through eye.	24-25 Legs shorter than gulls. Plunges into water with a splash when fishing. Wings slender, long pointed. 24 Tail deeply forked.	24 Orange at base, rest black.	Orange.
*25 Black Tern ........W.V. or S.V.	25 " " "	25 Upper parts black and dark gray and under parts black in summer. In winter upper parts dark gray, under parts, forehead, and back of neck white.	25 In winter, black spot back of eye.	25 Feed on insects even more than on fish.	25 Black.	Blackfish.

APPENDICES

MODERN BEAUFORT SCALE

Beaufort #	Wind Speed				Nautical Term	U.S. Weather Bureau Term	Hydrographic Office	
	knots	mph	meters per second	km per hour			Term & height of waves, in ft.	Code
0	under 1	under 1	0.0-0.2	under 1	Calm		Calm, 0	0
1	1-3	1-3	0.3-1.5	1-5	Light air		smooth, less than 1	1
2	4-6	4-7	1.6-3.3	6-11	Light breeze		Slight, 1-3	2
3	7-10	8-12	3.4-5.4	12-19	Gentle breeze	Gentle	Moderate, 3-5	3
4	11-16	13-18	5.5-7.9	20-28	Moderate breeze	Moderate	Rough 5-8	4
5	17-21	19-24	8.0-10.7	29-38	Fresh breeze	Fresh		
6	22-27	25-31	10.8-13.8	39-49	Strong breeze	Strong		
7	28-33	32-38	13.9-17.2	50-61	Moderate gale		Very rough 8-12	5
8	34-40	39-46	17.2-20.7	62-74	Fresh gale	Gale		
9	41-47	47-54	20.8-24.4	75-88	Strong gale		High, 12-20	6
10	48-55	55-63	24.5-28.4	89-102	Whole gale	Whole Gale	Very high, 20-40	7
11	56-63	64-72	28.5-32.6	103-117	Storm		Mountainous, 40 & higher	8

Beufort #	Wind Speed				Nautical Term	U.S. Weather Bureau Term	Hydrographic Office	
	knots	mph	meters per second	km per hour			Term & height of waves, in ft.	Code
12	64-71	73-82	32.7-36.9	118-133	Hurri-cane	Hurricane	Confused	9
13	72-80	83-92	37.0-41.4	134-149				
14	81-89	93-103	41.5-46.1	150-166				
15	90-99	104-114	46.2-50.9	167-183				
16	100-108	115-125	50.0-56.0	184-201				
17	109-118	126-136	56.1-61.2	202-220				

Adapted from N. Bowdith (1958 ed.), American Practical Navigator, U.S. Navy Hydrographic Office Publication No. 9, p. 1059.

ARTIFICIAL SEA (SALT) WATER

Many times the availability and collecting of natural sea water is a difficult task for the classroom teacher. The following is offered to augment the marine science program when this occurs.

*A. To 1 liter of distilled water add the following:

$NaCl$	27.2 gms
$MgCl$	1.6 gms
$MgSO_4$	3.8 gms
$CaSO_4$	1.3 gms
$CaCO_3$	0.1 gms
KSO_4	0.9 gms
$MgCO_3$	0.1 gms

Mix thoroughly and allow to stand overnight.

If evaporation occurs add sea water or distilled water to bring water up to original level in tank.

B. To 10 gallons of distilled water add the following:

$NaCl$	45.5 oz
KCl	1.25 oz
$CaCl$	2.00 oz
MgS	11.50 oz
$MgCl$ (anhyd)	8.75 oz

*Has proven in the past to be a more successful substitute for sea water.

Bicarbonate Soda	0.20 oz	

When this has been mixed thoroughly add the following:

KNO_3	0.20 oz	
$NaPO_4$	10	grains
$FeCl_3$	10	grains

Mix thoroughly and allow to stand overnight.

COLLECTING NATURAL SEA WATER

The following suggestions are offered for the collecting and storage of natural sea water.

1. Collect in glass or plastic containers.
2. Filter upon arrival back in the laboratory.
3. Store in dark containers.

EQUIVALENT MEASURES OF THE METRIC SYSTEM-TABLE 1

Metric	English
Length*	
1 meter = 39.370 inches	1 inch = .0254 meters
= 3.281 ft.	1 foot = .3048 meters
= 1.093 yd.	1 yard = .9144 meters

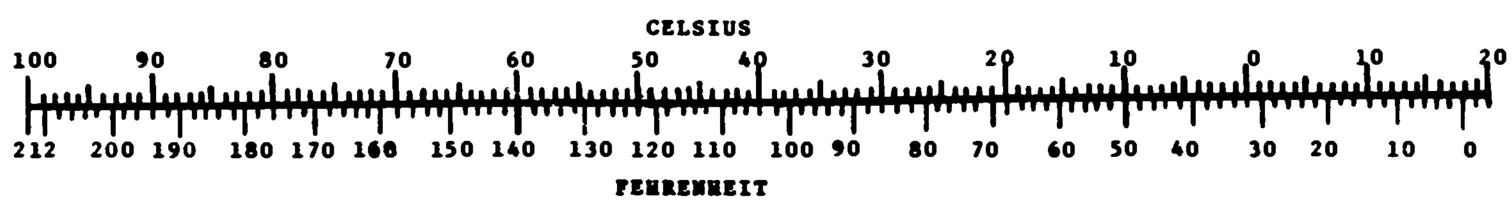
*Microscopic measurements;

1 micron = 1/1000 mm or 1/1,000,000 meter

1 angstrom unit = 1/10,000 micron or 1/100,000,000 centimeter

CONVERSION FACTORS

Metric →		English
centimeters	.3937	inches
meters	1.09361	yards
kilometers	.62137	miles
liters	.2641794	gallons (US)
kilograms	2.204623	pounds
English →		**Metric**
inches	2.54	centimeters
yards	.9144	meters
miles	1.6093	kilometers
gallons (US)	3.785306	liters
pounds	.453592	kilograms

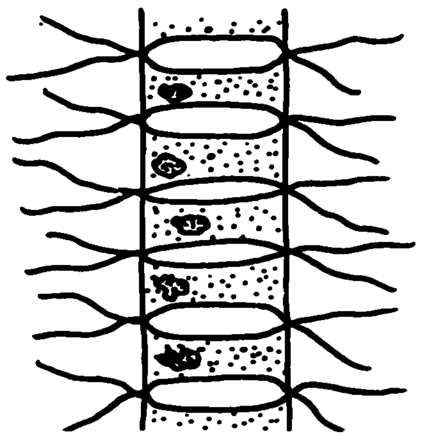


E X A M P L E S   O F

GENERALIZED OCEANIC PLANKTERS

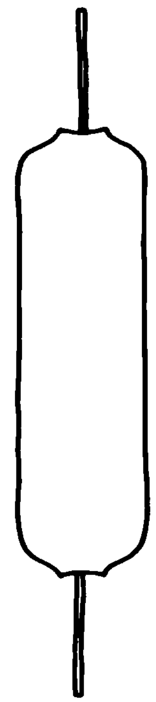
DIATOMS

(Phytoplankters)



←0.025→
mm
Chaetoceros

↔
0.02 mm
Coscinosira

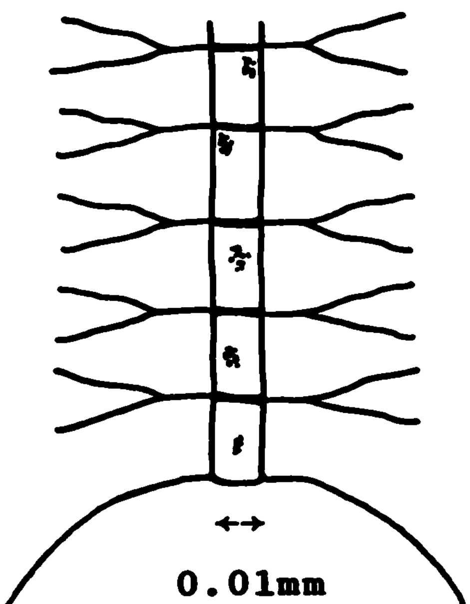


0.25
mm

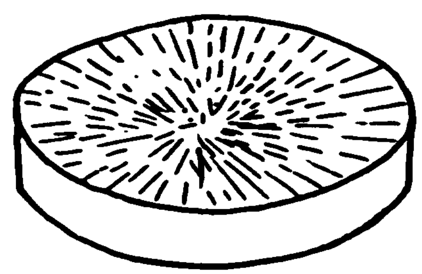
Ditylium

1.1mm

Rhizosolenia



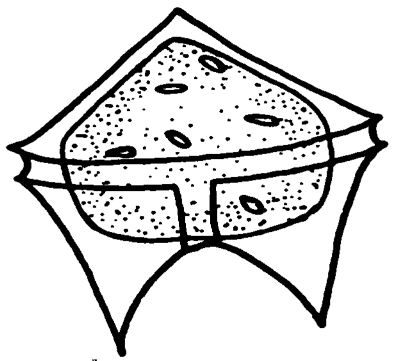
↔
0.01mm
Chaetoceros



←— 0.2mm —→
Coscinodiscus

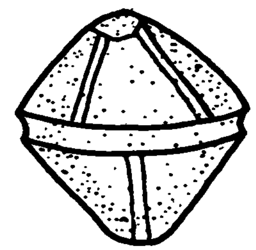
DINOFLAGELLATES

(Phytoplankters)



← 0.08 → mm

Peridinium



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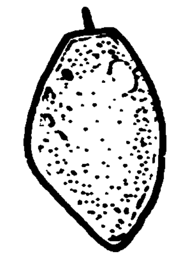
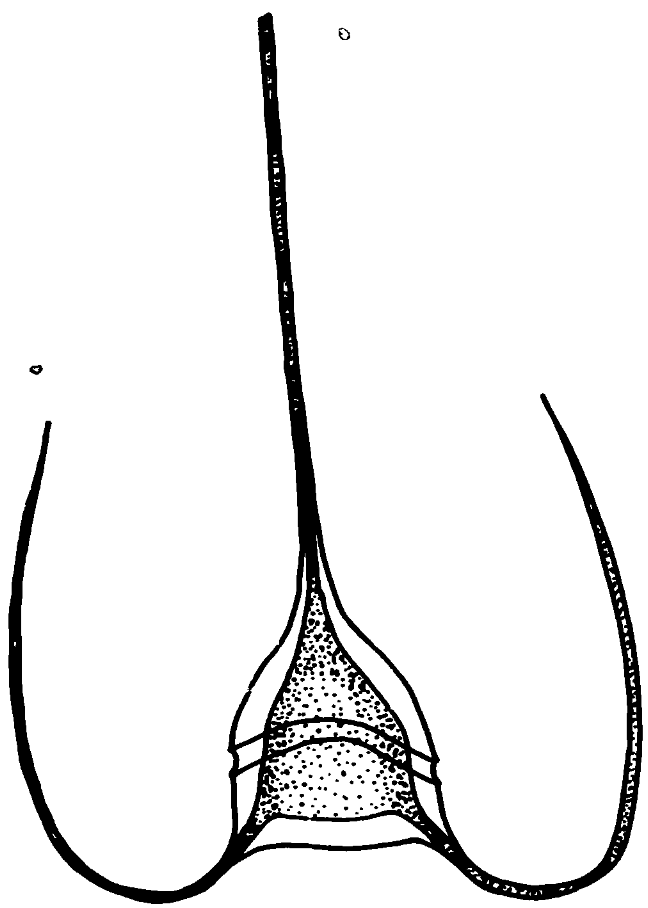
Goniaulax



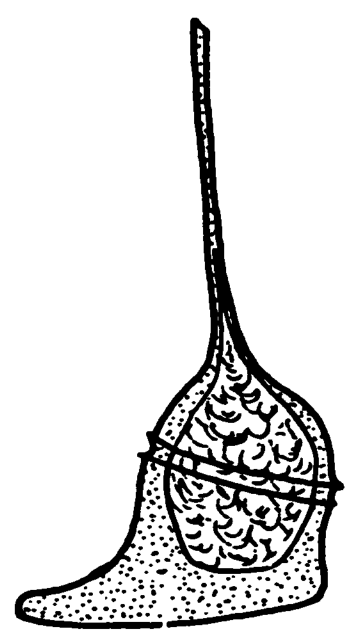
0.05mm

Porocentrum



←0.06→ mm

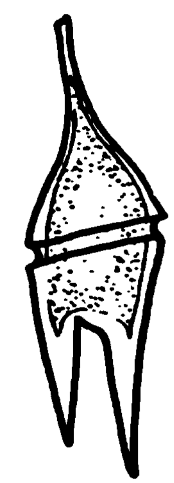
a.



0.14mm

← 0.06 → mm

b.



0.1 mm

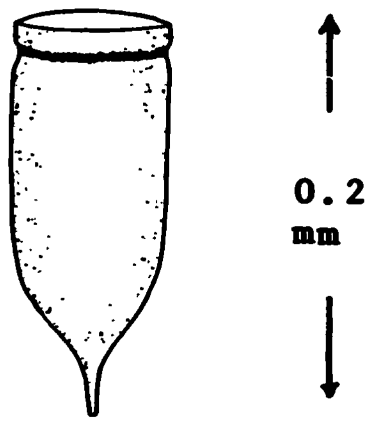
c.

0.2mm

d.

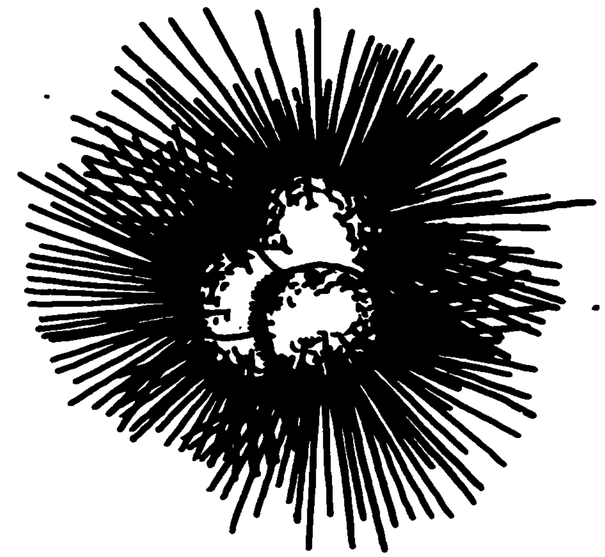
PERMANENT ZOOPLANKTERS

Examples of Hydrozoan Coelenterates



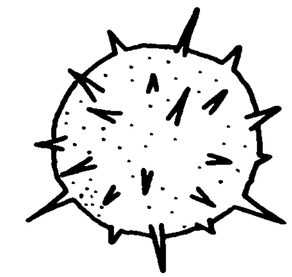
←0.08→
mm

Favella (Tintinnida: Protoza)
(shell only illustrated)



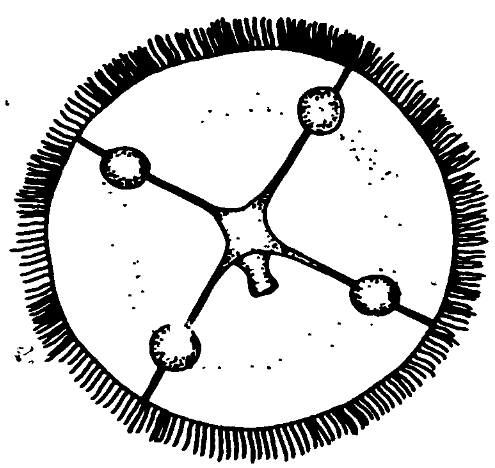
←0.4→
mm
Globigerina

(Foraminifera: Protozoa)

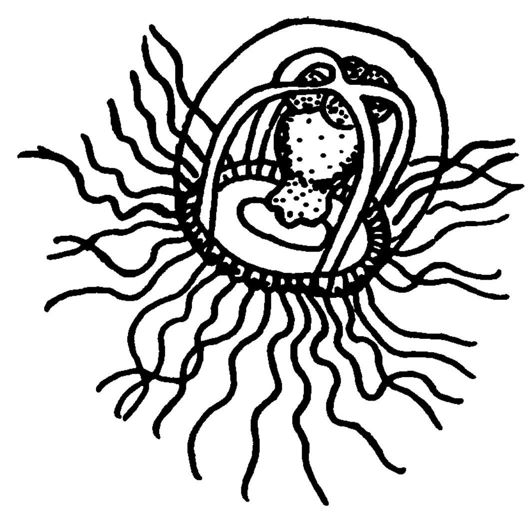


←0.18→
mm
Acanthosphaera

(Radiolaria: Protozoa)

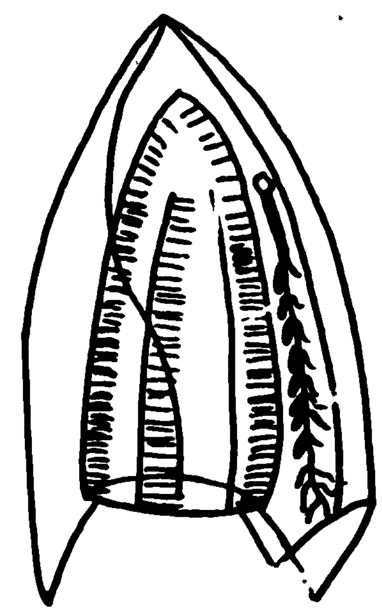


←3.2mm→
Leptomedusa



←2.3mm→

Anthomedusa



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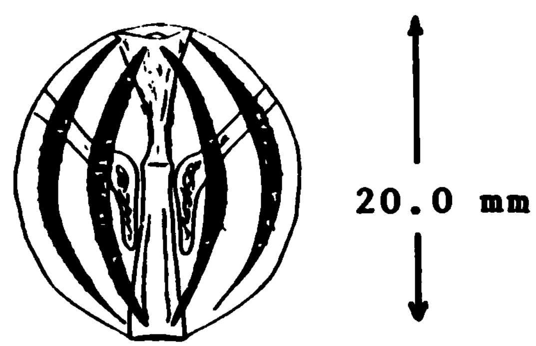
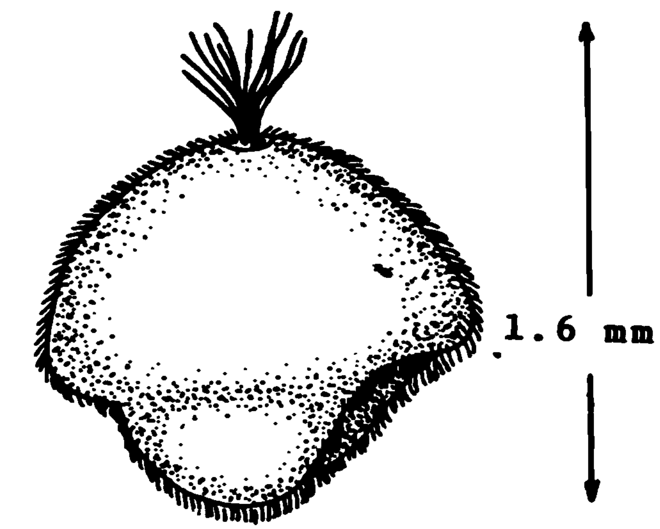
Siphonophora

TEMPORARY ZOOPLANKTERS

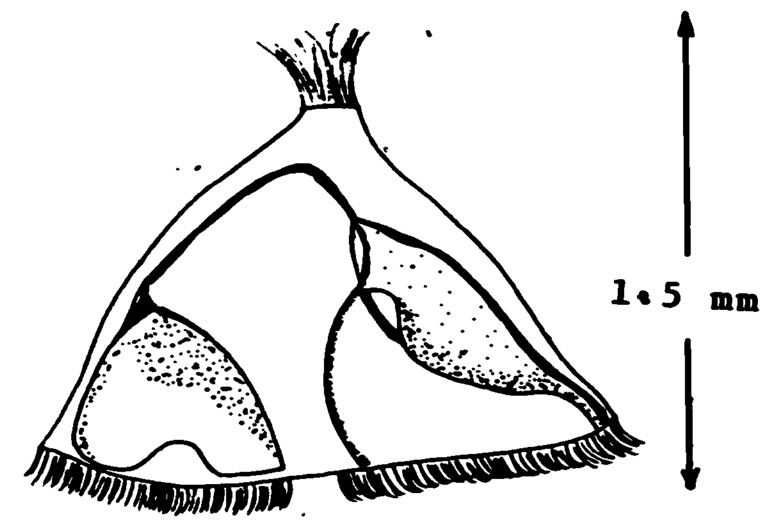
(Larvae)



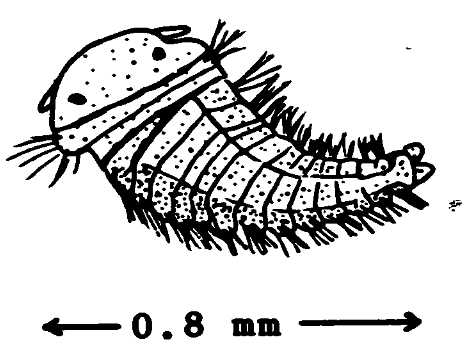
Pleurobrachia (Tenophora)



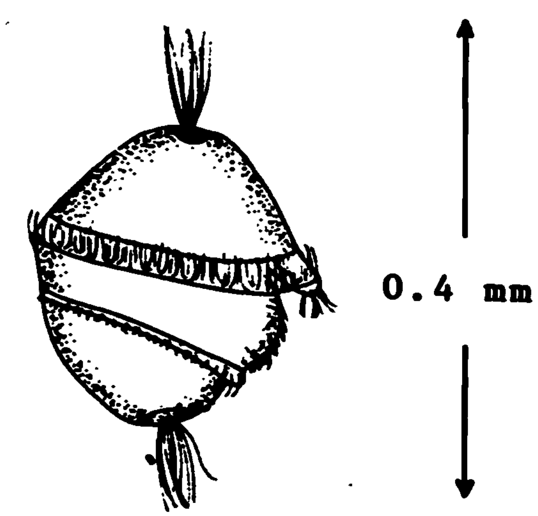
Pilidum Larva of ribbon worm
(Nemertina)



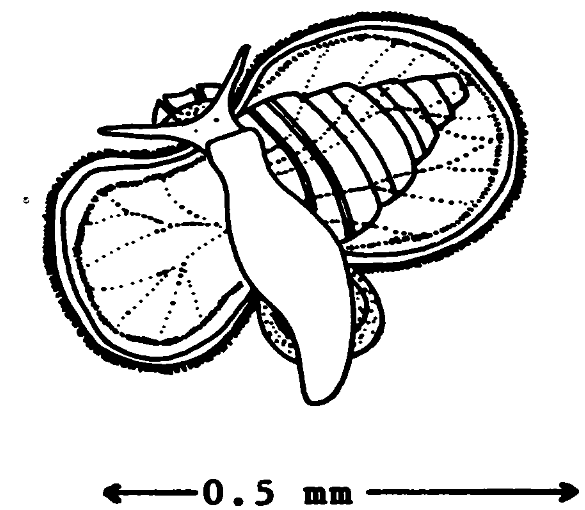
Cyphonautes Larva
of moss animal
(Bryozoa)



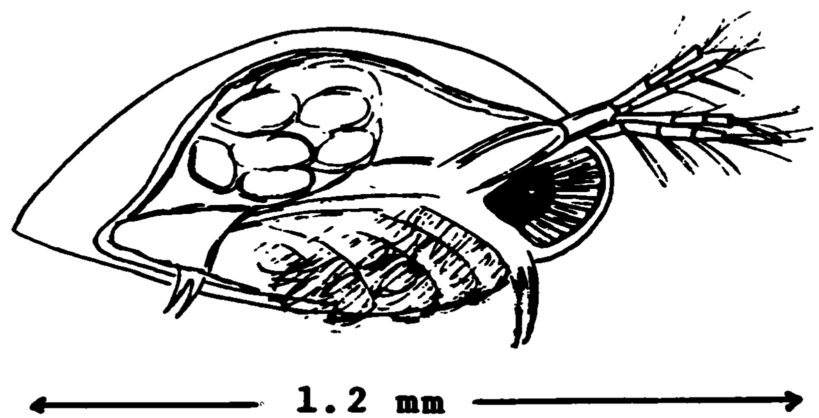
Pre-setting larva of
polychaete worm
(Polychaeta: Annelida)



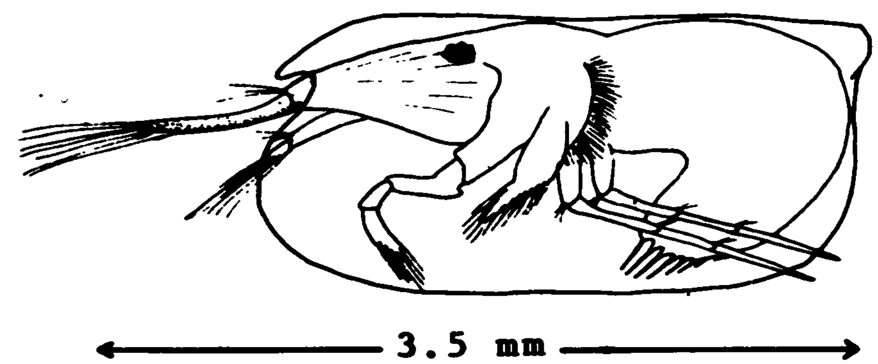
Trochophore Larva
of polychaete worm
(Polychaeta: Annelida)



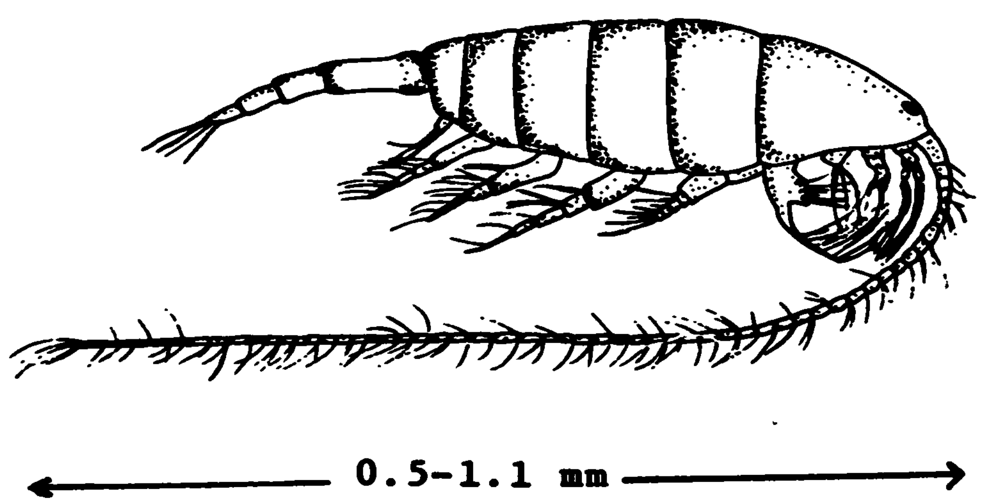
Late veliger larva
of snail
(Gastropoda: Mollusca)



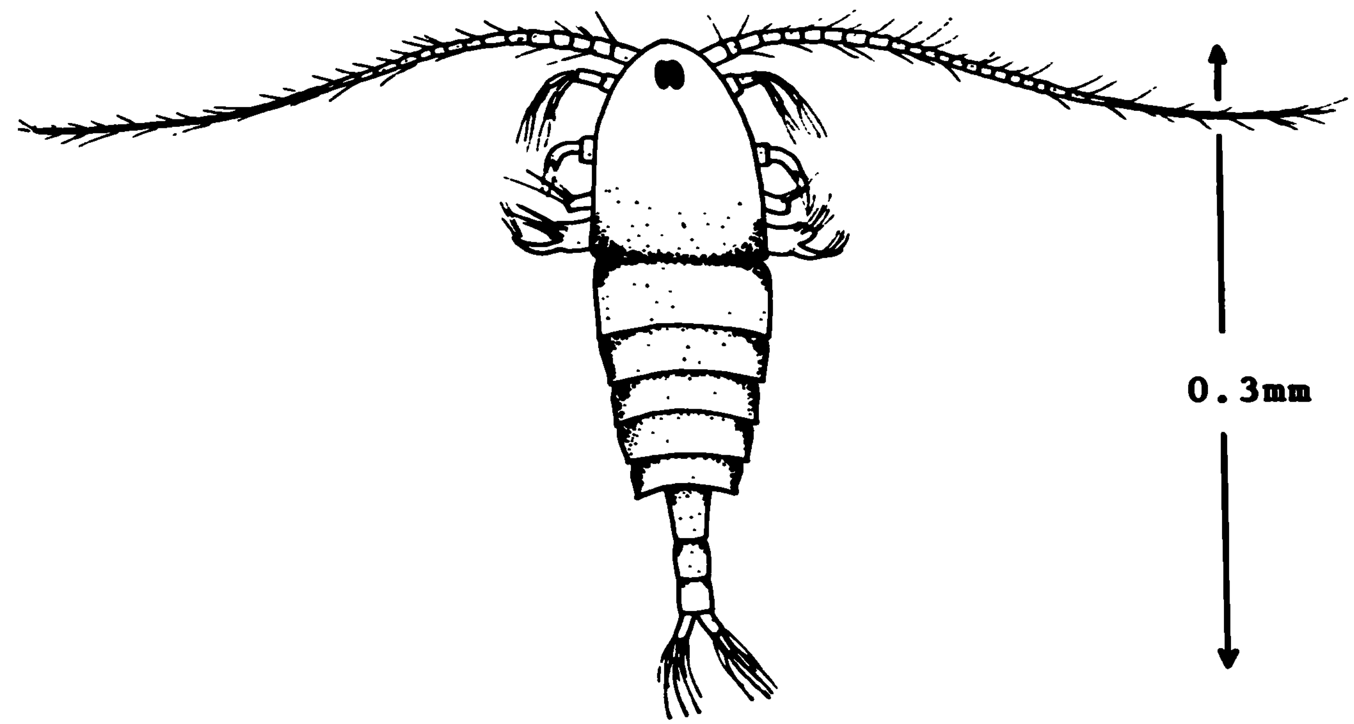
Evadne (Cladocera: Crustacea)



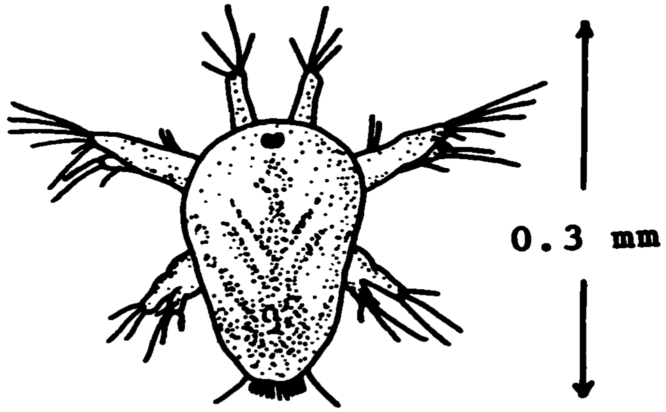
Conchoecia (Ostracoda: Crustacea)



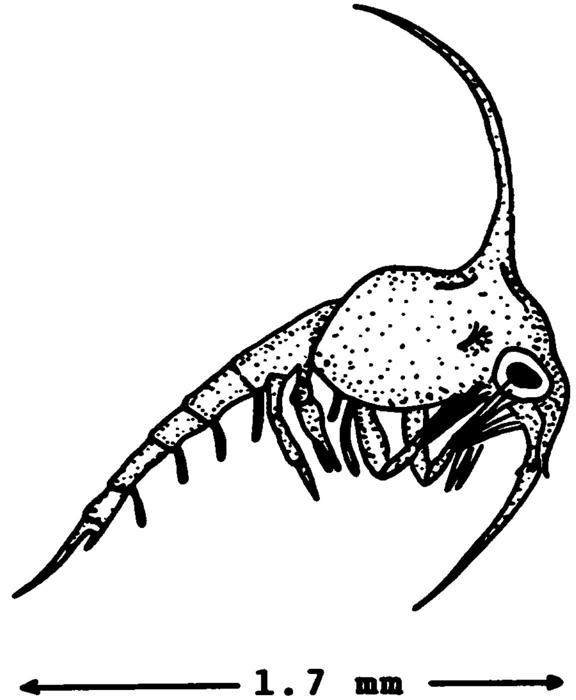
Calanus (Copepoda:Crustacea)



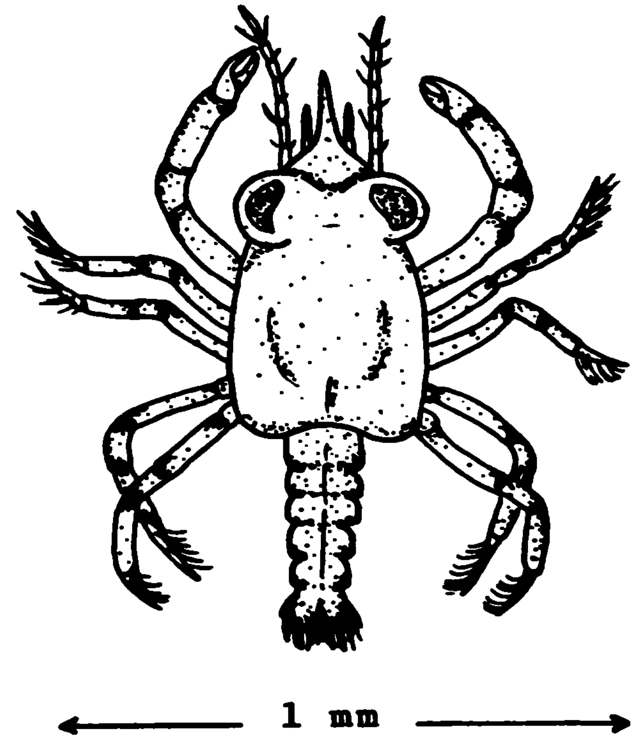
Calanus (Copepoda:Crustacea)



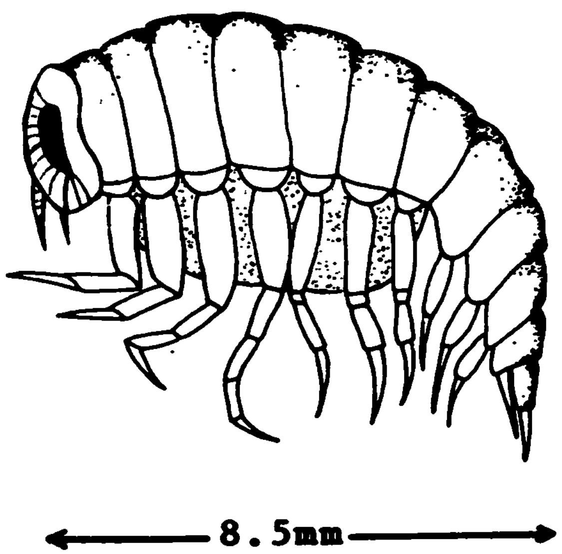
Nauplius larva of crab
(Decapoda: Crustacea)



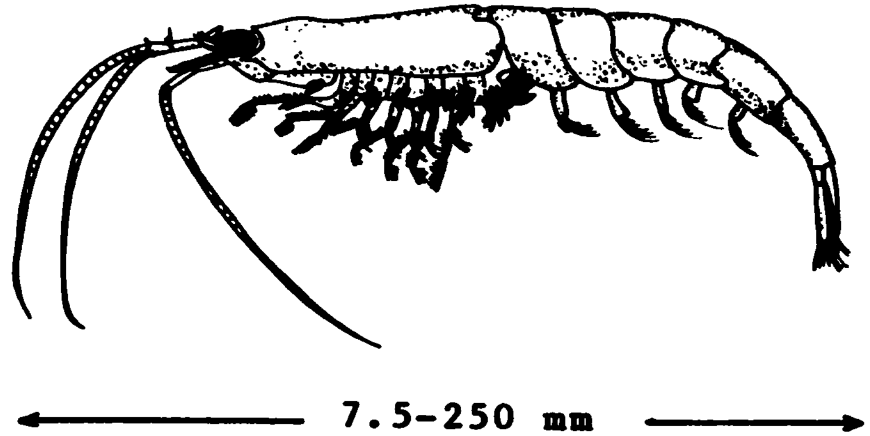
Zoea larva of crab
(Decapoda: Crustacea)



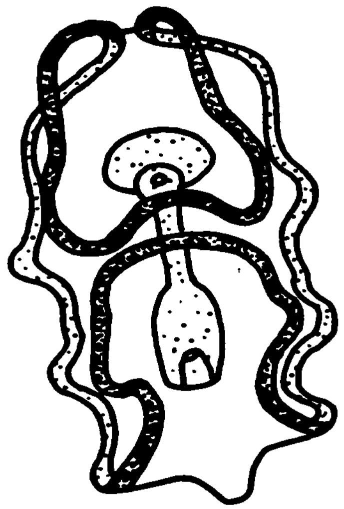
Megalops larva of crab
(Decapoda: Crustacea)



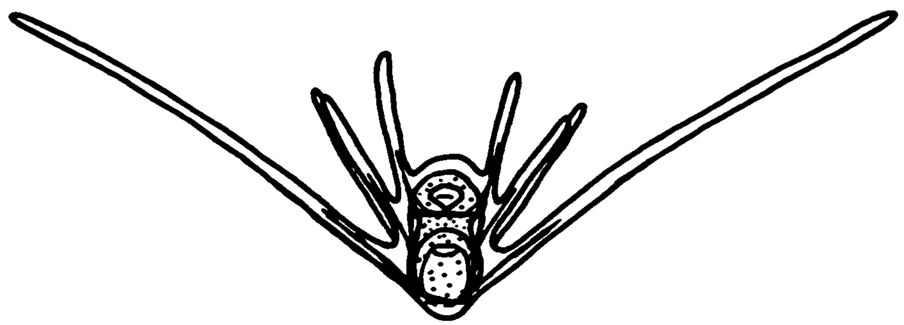
Hyperia (Amphipoda Crustacea)



Euphausia (Euphausiacea: Crustacea)

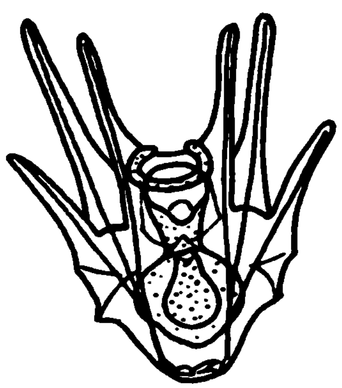


Auricularia larva of sea cucumber (Holothuroidea: Echinodermata)

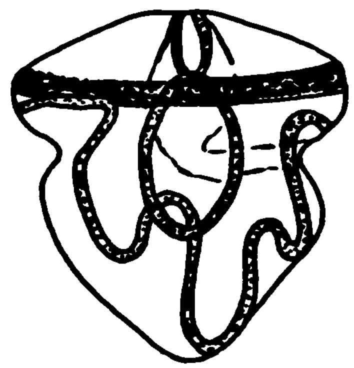


Ophiopluteus larva of brittle star (Ophiuroidea: Echinodermata)

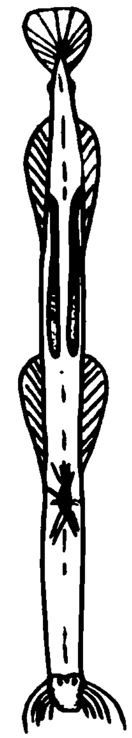
Brachiolaria larva of starfish (Asteroidea: Echinodermata)



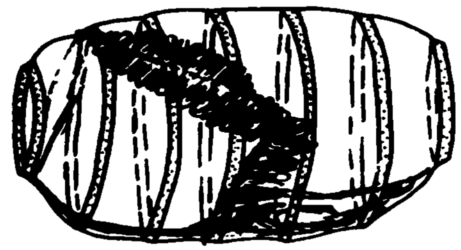
Echinopluteus larva of sea urchin (Echinoidea: Echinodermata)



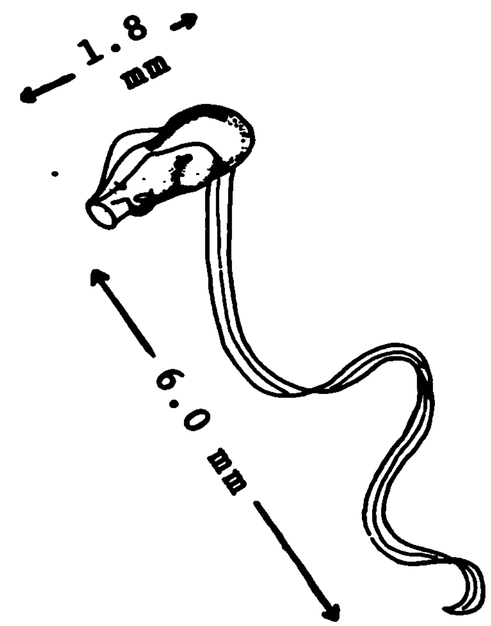
Tornaria larva of acornworm (Enteropneusta: Hemichordata)



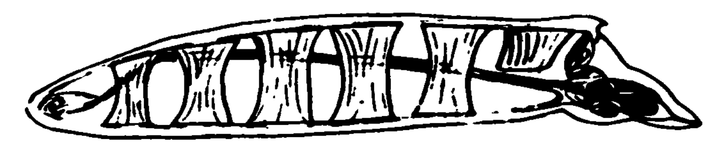
Sagitta (Chaetognatha)



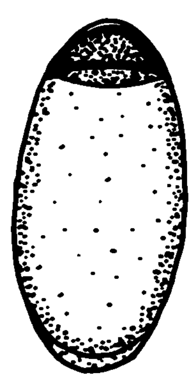
Doliolum (Tunicata)



Oikopleura (Tunicata)

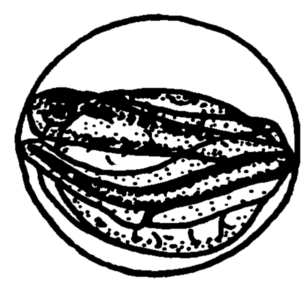


Salpa (Tunicata)

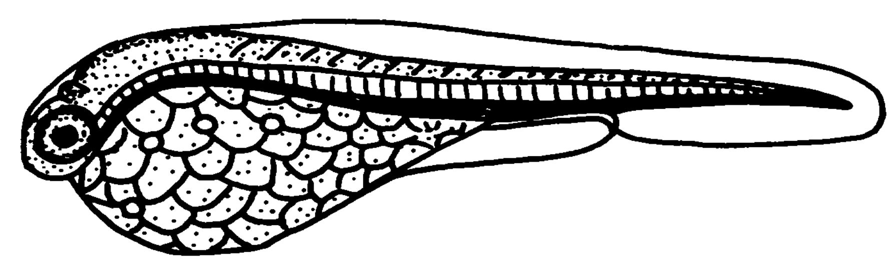


Egg of Anchovy

Anchoa



Pre-hatching embryo of anchovy, *Anchoa*



Yok-sac larva of anchovy

Anchoa

A GLOSSARY OF SOME COMMON OCEANOGRAPHIC TERMS

A GLOSSARY OF SOME COMMON OCEANOGRAPHIC TERMS

abyss - A particularly deep part of the ocean, or any part below 300 fathoms.

advection - In oceanography, advection refers to the horizontal or vertical flow of sea water as a current.

age of water - The time elapsed since a water mass was last at the surface and in contact with the atmosphere.

ambient - The environment surrounding a body but undisturbed or unaffected by it.

aphotic zone - That portion of the ocean waters where light is insufficient for plants to carry on photosynthesis.

aquaculture - Fish, shellfish, and algae farming.

archibenthic - A portion of the marine environment extending from a depth of 200 meters (continental edge) to 800-1100 meters.

archipelago - A sea or part of a sea studded with islands or island groups.

atoll - A ring-shaped organic reef enclosing a lagoon.

azoic - Without life.

baleen - The horny material growing down from the upper jaw of large plankton-feeding whales, which forms a strainer or filtering organ.

bar - A submerged or emerged embarkment of sand, gravel, or mud built on the sea floor in shallow water by waves and currents.

basin - A depression of the sea floor more or less equidimensional in form and of variable extent.

bathyal - A portion of the marine environmental ranging in depth from 180 to 3700 meters.

bathymeter - An instrument for measuring depth of water.

bathymetry - The science of measuring ocean depths in order to determine the sea floor topography.

bathypelagic - A depth zone of the ocean which lies between 900 and 3700 meters. A bathypelagic fish would be one which spent part of the time at the depth range mentioned.

Bathyscaphe - A free, manned vehicle for exploring the deep ocean.

Bathysphere - A spherical chamber in which persons are lowered for observation and study of ocean depths.

bathythermograph - (BT) A device for obtaining a record of temperature plotted against pressure or depth.

bay - A recess in the shore or an inlet of a sea.

beach - The zone of unconsolidated material extending inland from the low water line to where a marked change in material or permanent vegetation occurs.

bearing - The horizontal direction of one terrestrial point from another.

benthic - That portion of the marine environment inhabited by marine organisms which live in or on the bottom.

benthos - Bottom dwelling forms.

bioluminescence - Light produced by animals.

biomass - The amount of living material per unit of water surface or volume expressed in weight units.

bucket thermometer - A thermometer used to measure the temperature of a bucket of water drawn from the surface of the sea.

canyon - A relatively narrow, deep depression with steep slopes, the bottom of which grades continuously downwind.

chart - A special purpose map generally designed for navigation.

chlorinity - A measure of the chloride content, by mass, of sea water.

continental borderland - A region adjacent to a continent, normally occupied by or bordering a continental shelf, that is highly irregular with depths well in excess of those typical of a continental shelf.

continental drift - The hypothesis that continental masses are capable of moving relative to one another.

continental rise - A gentle slope with a generally smooth surface, rising toward the foot of the continental slope.

continental shelf - A zone adjacent to a continent or around an island, and extending from the low water line to the depth at which there is usually a marked increase of slope to greater depth.

continental slope - A declivity seaward from a shelf edge into greater depth.

core - A vertical, cylindrical sample of the bottom sediments from which the nature and stratification of the bottom may be determined.

Coriolis force - An apparent force on moving particles resulting from the earth's rotation. It causes the moving particles to be deflected to the right of motion in the Northern Hemisphere; the force is proportional to the speed and latitude of the moving particle and cannot change the speed of the particle.

deep scattering layer - The stratified population(s) of organisms in most oceanic waters which scatter sound. Commonly referred to as "DSL".

demersal-- Fishes which live on or near the bottom. Also, the eggs of certain bony fishes, which have a hard and smooth or adhesive membrane and sink to the bottom.

globigerina ooze - A pelagic sediment consisting of more than 30 percent calcium carbonate in the form of forminiferal tests of which Globigerina is the dominant genus.

gyre - Slowly rotating mass of surface water.

hadal - Pertaining to the greatest depths of the ocean.

halocline - A well-defined vertical gradient of salinity which is usually positive.

high water - The highest limit of the surface water level reached by the rising tide.

horse latitudes - The belts of latitude over the oceans at approximately 30° to 35° N and S where winds are predominantly calm or very light and weather is hot and dry.

hydrography - That science which deals with the measurement and description of the physical features of the oceans, seas, lakes, rivers, and their adjoining coastal areas, with particular reference to their use for navigational purposes.

isobath - A contour line connecting points of equal water depths on a chart.

isohaline - Of equal or constant salinity.

isotherm - A line on a chart connecting all points of equal or constant temperature; an isopleth of temperature

isthmus - A narrow strip of land, bordered on both sides by water, that connects two larger bodies of land.

knoll - An elevation rising less than 1000 meters from the sea floor, and of limited extent across the summit.

knot - A speed unit of one nautical mile (6,076.12 feet) per hour. It is equivalent to a speed 1.688 feet per second or 51.4 centimeters per second.

lateral line - A system of sense organs possessed by fishes, usually arranged in a single series along the side of the body, and functioning in part to detect low frequency vibrations such as those produced by local disturbances in the water.

littoral zone - An area extending from shoreline to the edge of the continental shelf or to the 200 meter depth line.

macroplankton - Plankton organisms within the size range 1 millimeter to 1 centimeter. Sometimes referred to as mesoplankton.

megaloplankton - Plankton larger than 1 centimeter; includes the larger forms of the plankton, such as salps and large jellyfishes.

meridian- A north-south reference line, through the geographical poles of the earth from which longitudes and azimuths are measured.

meroplankton - Chiefly the floating developmental stages (eggs and larvae) of the benthos and nekton. These forms are especially abundant in neritic waters.

detritus - Any loose material produced directly from rock disintegration.

diatoms - Single celled microscopic plants forming a major component of plankton.

dinoflagellates - Single celled microscopic organisms possessing both plant and animal characteristics

diurnal - Daily, especially pertaining to actions which are completed within twenty-four hours and which recur every twenty-four hours; thus, most reference is made to diurnal cycles, variations, ranges, maximums, etc.

ebb current - The tidal current associated with the decrease in the height of a tide. Ebb currents generally set seaward, or in an opposite direction to the tide progression. Erroneously called ebb tide.

echogram - The graphic presentation of echo soundings recorded as a continuous profile of the bottom.

echo sounding - Determination of the depth of water between emission of a sonic or ultrasonic signal and the return of its echo from the bottom. The instrument used for this purpose is called an echo sounder.

epipelagic - The upper portion of the oceanic province, extending from the surface to a depth of about 200 meters.

escarpment - An elongated and comparatively steep slope of the sea floor, separating flat or gently sloping areas.

estuary - A tidal bay formed by submergence or drowning of the lower portion of a nonglaciated river valley and containing a measurable quantity of sea salt.

eulittoral zone - According to some authorities a zone extending from the high tide level to a depth of about 40 to 60 meters.

euphotic zone - The layer of a body of water which receives ample sunlight for the photosysthesis processes of plants.

falling tide - The portion of the tide cycle between high water and the following low water.

fathogram - The graphic presentation of the bottom profile determined by a Fathometer. Also, often erroneously applied to any echogram.

fathom - The common unit of depth in the ocean for countries using the English system of units, equal to 1.83 meters.

fetch - An area of the sea surface over which seas are generated by a wind having a constant direction and speed. Also,the length of the fetch area, measured in the direction of the wind in which the seas are generated.

flood current - The tidal current associated with the increase in the height of a tide. Flood currents generally set toward the shore, or in the direction of the tide progression. Erronously called flood tide.

Globigerina - A common form of sediment-producing forminiferan.

mesopelagic - That portion of the oceanic province extending from about 200 meters down to a depth of about 1000 meters.

mesoplankton - Plankton within the size range 0.5 to 1.0 millimeter. Rarely used in this meaning since it is also used to designate all plankton living in middepths.

microplankton - Plankton within the size range 60 microns to 1 millimeter. Most phytoplankton forms are included in this group and the nannoplankton.

midocean ridge - A great median arch or sea bottom swell extending the length of an ocean basin and roughly paralleling the continental margins.

Mohorovicic discontinuity (Moho) - The sharp discontinuity in composition between the outer layer of the earth (the crust) and the next inner layer (the mantle). This was discovered by Mohorovicic from seismograms. The thickness of the crust has been determined by the refraction of seismic waves at this discontinuity which is situated about 35 kilometers below the continents and about 10 kilometers below the ocean basins and defines the top of the mantle.

mutualism - A symbiotic relationship between two species in which both are benefitted. An example of mutualism is the attachment of certain sponges and coelenterates to the shells of crabs. The attached animal is carried about to fresh feeding areas, and the crab is camouflaged by the animal on its back and may be thus protected from enemies.

myctophid - One of a family (Myctophidae) of small oceanic fishes which normally live at depths between about 200 and 4000 meters. They characteristically have numerous small photophores on the sides of the body. Many species undergo extensive diurnal vertical migrations and are thought to contribute to sound scattering layers in the sea.

nannoplankton - Plankton within the size range 5 to 60 microns. Includes many dinoflagellates and smaller diatoms. Individuals will pass through most nets and usually are collected by centrifuging water samples. This spelling is as originally coined; the spelling nanoplankton used by some authorities is etymologically correct.

nautical mile - In general a unit used in marine navigation equal to a minute of arc of a great circle on a sphere. Depending upon the radius of the sphere, various lengths of nautical miles have been defined. The adopted value in the United States since July 1, 1959 is one international nautical mile equals 6,076.11549 U.S. feet (approximately).

neap tide - Tide of decreased range which occurs about every two weeks when the moon is in quadrature.

nekton - Those animals of the pelagic division that are active swimmers, such as most of adult squids, fishes, and marine mammals.

neritic - That portion of the pelagic division extending from low water level to the approximate edge of a continental shelf. Some writers have used this term in describing bottom organisms of a continental shelf, but its recommended usage is restricted to the waters overlying a shelf.

nodules - Concretionary lumps of manganese, cobalt, iron, and nickel found widely scattered on the ocean floor. Rocks of various sizes and shapes often are encrusted with these metals.

ocean - 1. The intercommunicating body of salt water occupying the depressions of the earth's surface.
2. One of the major primary subdivisions of the above, bounded by continents, the Equator, and other imaginary lines.

oceanic - That portion of the pelagic division seaward from the approximate edge of a continental shelf.

oceanography - 1. The study of the sea, embracing and integrating all knowledge pertaining to the sea's physical boundaries, the chemistry and physics of sea water, and marine biology.
2. In strict usage oceanography is the description of the marine environment, whereas oceanology is the study of the oceans and related sciences.

offshore current - A prevailing nontidal current usually setting parallel to the shore outside the surf zone.

offshore wind - A wind blowing seaward from the land in a coastal area; a land breeze.

onshore - A direction landward from the sea.

onshore wind - A wind blowing landward from the sea in a coastal area; a sea breeze.

ooze - 1. A soft mud or slime.
2. A fine-grained pelagic sediment containing undissolved sand- or silt-sized, calcareous or siliceous skeletal remains of small marine organisms in proportion of 30 percent or more, the remainder being amorphous clay-sized material. Deep sea oozes often are characterized by markedly bi-modal grain-size distributions, one mode being in the sand or silt range, the other in the clay range.

oxygen minimum layer - Region in which O_2 content of ocean water is low.

pelagic division - A primary division of the sea which includes the whole mass of water. The division is made up of the neritic province which includes the water shallower than 200 meters, and the oceanic province which includes that water deeper than 200 meters.

phytoplankton - The plant forms of plankton. They are the basic synthesizers of organic matter (by photosynthesis) in the pelagic division. The most abundant of the phytoplankton are the diatoms.

pinnacle - A sharp pyramidal or cone-shaped rock partly or completely covered by water. Also a small coral spire which lies near the water surface in a lagoon.

plankter - A single organism in the plankton.

plankton - The passively drifting or weakly swimming organisms in marine and fresh waters. Members of this group range in size from microscopic plants to jellyfishes measuring up to 6 feet across the bell, and included the eggs and larval stages of the nekton and bethos. See phytoplankton, zooplankton.

plankton bloom - An enormous concentration of plankton (usually phytoplankton) in an area, caused either by an explosive or a gradual multiplication of organisms (sometimes of a single species) and usually producing an obvious change in the physical appearance of the sea surface, such as discoloration. Blooms consisting of millions of cells per liter often have been reported. See red tide.

plateau - A comparatively flat-topped elevation of the sea floor of considerable extent across the summit and usually rising more than 200 meters on all sides.

pneumatocyst - An air or gas bladder or float; structures so called in siphonophores and in several species of brown algae. Also spelled neumatocyst.

red tide - A red or reddish-brown discoloration of surface waters, most frequently in coastal regions, caused by concentrations of certain microscopic organisms, particularly dinoflagellates. Toxins produced by the dinoflagellates can cause mass kills of fishes and other marine animals. Airborne particles which are optic and respiratory irritants to humans and animals, may be carried from red tide areas overland. Red tides may develop rapidly, apparently as a result of an abrupt change in one or more

red tide - (cont.) environmental factors. In some regions at least, notably off the west coast of Florida, the onset of red tide appears to follow increased rainwater runoff from the land; the introduction by this means of one or more scarce nutrient elements into the sea is believed to permit the dinoflagellates to multiply rapidly.

reef - An offshore consolidated rock hazard to navigation with a least depth of 20 meters or less.

ridge - A long narrow elevation of the sea floor with steep sides and irregular topography.

rip current - The return flow of water piled up on shore by incoming waves and wind; a strong narrow surface current flowing away from the shore. A rip current consists of three parts: the feeder flowing parallel to the shore inside the breakers; the neck, where the feeder currents converge and flow through the breakers in a narrow band or "rip"; and the head, where the current widens and slackens outside the breaker line.

rising tide - The portion of the tide cycle between low water and the following high water.

__salinity__ - A measure of the quantity of dissolved salts in sea water. It is formally defined as the total amount of dissolved solids in sea water in parts per thousand ($^o/oo$) by weight when all the carbonate has been converted to oxide, the bromide and iodide to chloride, and all organic matter is completely oxidized.

__sea floor__ - The bottom of the ocean where there is a generally smooth, gentle gradient. In many uses depth is disregarded and the term may be used to designate areas in basins or plains or on the continental shelf.

__seamount__ - An elevation rising 1000 meters or more from the sea floor and of limited extent across the summit.

__seamount range__ - Several seamounts having connected bases and aligned along a ridge or rise.

__sediment__ - Particulate organic and inorganic matter which accumulates in a loose unconsolidated form. It may be chemically precipitated from solution, secreted by organisms, or transported by air, ice, wind, or water and deposited.

__sedimentary basin__ - A depression, often marine, in which sediments are deposited. The deposits are usually thickset in the center and thinner toward the edges.

__sedimentary rocks__ - Rocks formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The sediment may consist of rock fragments or particles of various sizes (conglomerate, sandstone, shale); of the remains or products of animals or plants (certain limestones and coal); of the product of chemical action or of evaporation (salt, gypsum, etc.); or of mixtures of these materials.

__seismograph__ - An instrument used to measure and record earthquake vibrations and other earth tremors.

__semidiurnal__ - Having a period or cycle of approximately half a lunar day (12.42 solar hours). The tides and tidal currents are semidiurnal when two flood and two ebb periods occur each lunar day.

__shoal__ - A submerged ridge, bank, or bar consisting of or covered by unconsolidated sediments (mud, sand, gravel) which is at or near enough to the water to constitute a danger to navigation.

__spring tide__- Tide of increased range which occurs about every two weeks when the moon is new or full.

__stenohaline__ - Capable of existence only within a narrow range of salinity, as certain marine organisms.

__stenothermic__ - Tolerant of only a very narrow range of temperature.

__sublittoral__ - That benthic region extending from mean low water to a depth of about 200 meters, or the edge of a continental shelf.

__surf__ - Collective term for breakers.

__surge__ - The name applied to wave motion with a period intermediate between that of the ordinary wind wave and that of the tide, from about ½ to 60 minutes. It is of low height, usually less than 0.3 foot.

terrace - A bench-like structure bordering an undersea feature.

test - The hard covering or supporting structure of many invertebrates, it may be enclosed within an outer layer of living tissue; a shell.

thermocline - A vertical negative temperature gradient in some layer of a body of water, which is appreciable greater than the gradients above and below it; also a layer in which such a gradient occurs. The principal thermoclines in the ocean are either seasonal, due to heating of the surface water in summer, or permanent.

thermohaline - Pertaining to both temperature and salinity acting together; for example, thermohaline circulation.

tidal basin - A basin affected by tides, particularly one in which water can be kept at a desired level by means of a gate.

tidal current - The alternating horizontal movement of water associated with the rise and fall of the tide caused by the astronomical tide-producing forces.

tidal scour - The erosion of the bottom by tidal currents with formation of deep channels and holes.

tide - The periodic rising and falling of the earth's oceans and atmosphere. It results from the tide-producing forces of the moon and sun acting upon the rotating earth. This disturbance actually propagates as a wave through the atmosphere and through the surface layer of the oceans.

tide wave - A long-period wave associated with the tide-producing forces of the moon and sun; identified with the rising and falling of the tide.

trench - A long, narrow and deep depression of the sea floor, with relatively steep sides.

tsunami - A long-period sea wave produced by a submarine earthquake or volcanic erruption. It may travel unnoticed across the ocean for thousands of miles from its point of origin and builds up to great heights over shoal water.

turbidity - Reduced water clarity resulting from the presence of suspended matter. Water is considered turbid when its load of suspended matter is visibly conspicuous, but all waters contain some suspended matter and therefore are turbid.

turbulence - A state of fluid flow in which the instantaneous velocities exhibit irregular and apparently random fluctuations, so that in practice only statistical properties can be recognized and subjected to analysis. These fluctuations often constitute major deformations of the flow and are capable of transporting momentum, energy, and suspended matter at rates far in excess of the rate of transport by molecular diffusion and conduction in a non-turbulent or laminar flow.

tychoplankton - Plankton consisting of animals and plants which have temporarily migrated or have been carried into the plankton from their normal benthic habitat.

undercurrent - A water current flowing beneath a surface current at a different speed or in a different direction.

upwelling - The process by which water rises from a lower to a higher depth, usually as a result of divergence and offshore currents.

volcanic island - An island formed by the materials ejected from the interior of the earth through a vent.

waterspout - Usually, a tornado occurring over water; rarely, a lesser whirlwind over water, comparable in intensity to a dust devil over land. Waterspouts are most common over tropical and subtropical waters.

wave - A disturbance which moves though or over the surface of the medium (here, the ocean), with speed dependent upon the properties of the medium.

wave crest - The highest part of a wave. Also that part of the wave above still water level.

wavelength - The distance between corresponding points of two successive periodic waves in the direction of propagation, for which the oscillation has the same phase. Unit of measurement is meters.

wave period - The time, in seconds, required for a wave crest to traverse a distance equal to one wavelength.

wave trough - The lowest part of a wave form between successive wave crests. Also that part of a wave below still water level.

zooplankton - The animal forms of plankton. They include various crustaceans, such as copepods and euphausiids, jellyfishes, certain protozoans, worms, mollusks, and the eggs and larvae of benthic and nektonic animals. They are the principal consumers of the phytoplankton, and in turn, are the principal food for a large number of squids, fishes, and baleen whales.

FIELD DATA SHEET

ORANGE COUNTY SCHOOLS MARINE SCIENCE FLOATING LABORATORY

Area Number__________

Station or Run Number______

Cruise Number__________

Vessel__________

Date__________

Lat.____ ° ____ ' ____ "

Long.____ ° ____ ' ____ "

Time__________

Current Meter

Depth__________

Velocity__________

Direction__________

Depth__________in fathoms

Wind Speed______Direction______

Turbity Index__________

pH______at______depth

O_2______at______depth

Salinity______at______depth

Water Color__________

Sky Conditions__________

Bottom Sediments

Type of Sediment__________

Color of Sediment__________

Temperature of Sediment______

Temperatures:

B.T. Slide Number__________

Air__________

Surface__________

5 M or 10 Ft.__________

10 M or 20 Ft.__________

15 M or 40 Ft.__________

20 M or 60 Ft.__________

Bottom______at____depth

Species Account:

General Comments:

PLANKTON IDENTIFICATION SUMMARY

A. Phytoplankton

1. Dinoflagellates:

2. Diatoms:

B. Zooplankton

1. Permanent

2. Temporary (larval)

ABUNDANCE OF PLANKTERS RELATIVE TO SEASONAL CHANGE

(under the appropriate heading list the most abundant plankters)

	Winter Dec.22-Mar.21	Spring Mar.22-June 21	Summer June 22-Sept.21	Fall Sept.22-Dec.21
1.				
2.				
3.				
4.				
5.				
6.				

FIELD DATA SHEET

ORANGE COUNTY SCHOOLS MARINE SCIENCE FLOATING LABORATORY

Area Number________________

Station or Run Number______

Cruise Number______________

Vessel____________________

Date_____________________

Lat.____ ° ____ ' ____ "

Long.____ ° ____ ' ____ "

Time ____________________

Current Meter

Depth__________________

Velocity________________

Direction_______________

Depth____________in fathoms

Wind Speed_______Direction______

Turbity Index__________________

pH__________at____________depth

O_2__________at____________depth

Salinity________at___________depth

Water Color___________________

Sky Conditions_________________

Bottom Sediments

Type of Sediment______________

Color of Sediment_____________

Temperature of Sediment_______

Temperatures:

B.T. Slide Number________

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5 M or 10 Ft._____________

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Bottom________at____depth

Species Account:

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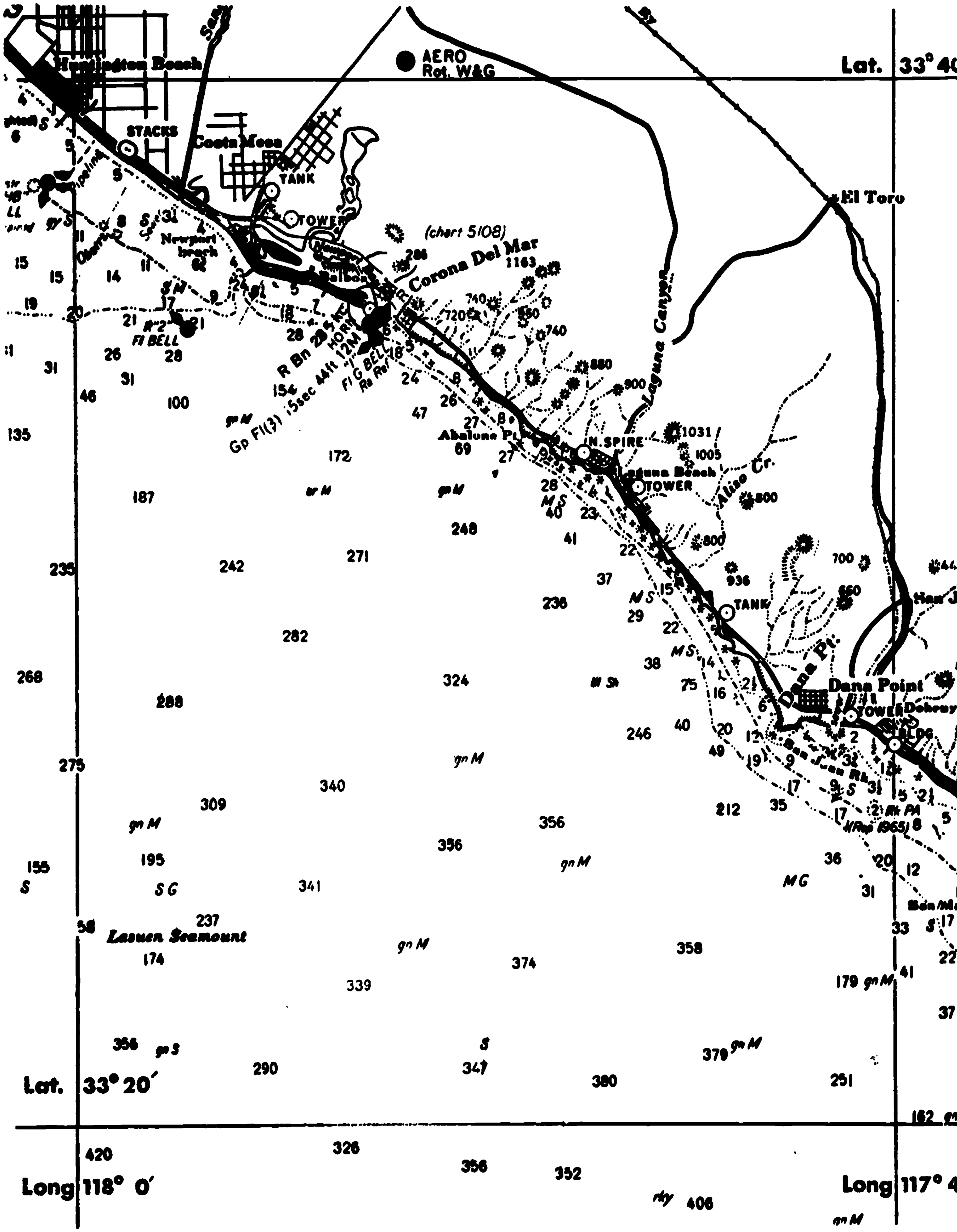

Huntington Beach
AERO Rot. W&G
Lat. 33° 40′
STACKS
Costa Mesa
TANK
TOWER
El Toro
Newport beach
Balboa
(chart 5108)
Corona Del Mar
Laguna Canyon
R Bn 285 kc HORN
Fl G BELL
Gp Fl(3) 15sec 44ft 12M
Fl BELL
Abalone Pt.
N. SPIRE
Laguna Beach
TOWER
Aliso Cr.
TANK
Dana Pt.
Dana Point
San Juan Rk.
Lasuen Seamount
Lat. 33° 20′
Long 118° 0′
Long 117° 40′